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OF

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PENROSE MEMORIAL LECTURE

IN NEED OF A CONSENSUS

J. WILLIAM FULBRIGHT

United States Senator from Arkansas

(*Read April 20, 1961*)

It is indeed an honor to be invited to address this venerable and distinguished society. Among its members, this Society has counted many of the outstanding men of this nation, men who have made significant contributions to the intellectual and the political life of our country. It is my impression that the greater emphasis has been on the intellectual, but inasmuch as Benjamin Franklin was a political figure as well as an intellectual of varied talents, apparently you have felt it appropriate from time to time to invite politicians into your circle. Whatever the reason may have been, I am grateful for the honor you have shown me.

The fact that I have had the good fortune to be married to a native of this city, enhances my appreciation of the honor. Not infrequently during the twenty-nine years of our married life, I have been reminded of the splendid qualities of Philadelphia in general and of the virtues of its citizens in particular. So, both as a public official and as an obedient and devoted husband, I am pleased and honored to be identified with this Society and this great city.

It was suggested, in view of my responsibility as Chairman of the Committee on Foreign Relations, that I address my remarks to some aspect of our foreign policy. I need not remind you that all Senators are members of at least two major committees and that if they expect to be re-elected they must interest themselves in the affairs of all their constituents, affairs which are as varied as the life of the nation itself. The problems of the cotton producer, the business man, and the pensioner compete for our attention with the current crisis, whether it be in Cuba, in Laos, in the Congo, or in Moscow. In short, foreign policy is not a thing apart from the domestic life of our people. Foreign policy is but one aspect of our national policy, and members of the Congress are not *ipso facto* specialists in foreign affairs. The President has primary responsibility in this field, both to initiate policy and to inform and educate the people relative thereto.

I have often said—and still believe—that a nation can conceive and execute a foreign policy that is responsive, courageous, and creative only to the extent that its people succeed in cultivating these same qualities in themselves. Thus, diplomatic style is necessarily a reflection of national style.

It is not enough to be powerful militarily and economically. An inept, clumsy national style can undermine military strength. Style and power are indivisible; they march together.

One looks to history in vain for a situation in which the problems were of comparable weight and gravity to those that the United States must shoulder in the sixties. Stated broadly, the responsibility is one of leadership. And it is not a problem just for the President and the Secretary of State, supported by the leadership in Congress. It is a collective one, dependent finally upon a consensus of a majority of our people.

The President, who is deeply read in the history and philosophy of democratic societies, tried to make this clear from the beginning. In Los Angeles last July, he defined his new frontier "not as a set of promises," but as "a set of challenges." He said, "it sums up not what I intend to offer the American people, but what I intend to *ask of them*. It appeals to their *pride*, not their pocketbook—it holds out the promise of more sacrifice instead of more security."

As we know, *scarcely half* of the electorate responded affirmatively to the challenge stated in those terms. The response to the challenge was, to say the least, *tentative*. Yet in that same speech in Los Angeles, the President said, correctly, that the new frontier of which he spoke is here, "whether we seek it or not."

That is, indeed, the case. What remains to be seen is whether the national mood will merge with the national responsibility. That was really

the central issue of the campaign. And it has by no means been fully resolved.

Erasmus, in *The Praise of Folly*, observed that he "who grasps the helm of great affairs . . . is one who is exposed to all eyes, and like a favorable star he has power, by the good influence of his conduct, to bring salvation in human affairs: or like a fatal comet he may bring destruction in his train."

The recent dramatic exploits of the Russians into the realm of the stars lends new meaning to Erasmus' observation. Many of us believe this "Red Star" the Soviets have created is not a "favorable star"; but, like a fatal comet, it may well be the precursor of the destruction of the free way of life which was initiated so successfully in this city in 1789, and to which occasion one of your founders contributed so much.

It has often been said by Americans, with a kind of detached diffidence tinged with a touch of self-righteousness, that the leadership of the free world has been thrust upon us, that we did not seek it.

It may well be true that we have *not* been an ambitious, power-seeking nation, although I suspect these assertions of innocence may be inspired by the desire to avoid the responsibility and burdens which go with power. But, in any case, even if true, it is irrelevant to the question of our present responsibility, in the words of Erasmus, "by the good influence of our conduct to bring salvation in human affairs."

In contrast to our tentative or even reluctant approach to power, the Russians boldly and aggressively grasp at every opportunity to expand their empire. I am not suggesting that we do likewise. I am suggesting that, as the leader of a free, pluralistic society of nations, we recognize and accept the leadership, that we engage *all* our faculties, in the contest. It is not enough to pay the bill, however burdensome that may be upon our taxpayers. Beyond this, we must strive to understand with our minds and our hearts the peoples with whom we are associated in this struggle.

Many thoughtful men have commented on the reasons for the unwillingness, or inability, of Americans to perceive the full sweep of their responsibilities. Some have put the problem in a deep historical perspective, suggesting that the national mood, like a pendulum, swings back and forth, with the citizenry making its full commitment to national problems only in times of crisis. Others speak of dreadful anxieties brought on by the psychology of life in the nuclear age, which cause people to turn their minds away from the uncongenial urgencies of the time.

Probably there is some validity in both of the theories that are offered to explain America's apathy. The national style is the sum of many attributes, attitudes, and characteristics. Among the most significant is the failure, by a large proportion of Americans, to identify what they regard as their own best interests with the national interest. For instance, a sizable number of Americans continue to view foreign aid, not as a contribution ultimately to their own security, but as they say, as "a give-away program." Nor do they understand or appreciate the markets for American goods that foreign aid is helping to create abroad. Some oppose reciprocal trade legislation, thus failing to understand that the American economy, like most others, depends for much of its vigor on the free flow of goods among the nations just as among our several states. Instead of trying to compete abroad, many American businessmen seek to discourage the inflow here of foreign manufactured goods.

The farmers of America have been among the most consistent detractors of our commitments abroad. Yet, farmers are among the greatest direct beneficiaries of our external policies. American cotton producers, for instance, have always depended upon foreign markets, and the industry has traditionally exported roughly half the crop. The figures show that in my own state of Arkansas, 750,000 bales—half of the State's total production—were sold abroad in 1959.

This is a large country, larger by far than any contemplated by Erasmus. Divided as it is along regional, cultural, and economic lines, national *consensus* is an elusive goal. The various economic and sectional interests have often seemed to be in conflict, and, except in time of national crisis, they have rarely been brought together into a purposeful whole. Thus, whatever the pressures on the economy, we can rely on labor unions to demand broader welfare programs, on farm organizations to seek high subsidies, on the business community to lobby for a more congenial tax structure. We can also rely on many millions of other Americans to identify their points of view with organizations that reflect their social and political attitudes.

It has been suggested that the size and complexity of the United States is such that it is beyond the comprehension of the citizens, that the nation is too abstract and remote a concept

to arouse and attract their loyalty. In time of crisis such as war, this has not been true, but it is true that we have in this country an unprecedented number of organizations, thousands of them which seem to attract the energies and the devotion, a part of which at least, in smaller countries, is accorded the nation.

This is good to the extent that it reflects participation of the citizenry in public affairs. And it is an inherent part of our processes, as Calhoun was among the first to recognize. His "*Doctrine of Concurrent Majorities*" suggests that government "must prevent any one interest or combination of interests from using the powers of government to aggrandize itself at the expense of others." Calhoun further suggested that each "division or interest" should have "either a concurrent voice in making and executing the laws or a veto on their execution."

In the broad sense, this theory has prevailed in the United States. And it helps to explain the diversity of our two major political parties. But the tacit acceptance of Calhoun's *modus vivendi* imposes an added responsibility on our citizens. It means that each of the so-called interests of which Calhoun spoke must on occasion be voluntarily subordinated to the national interest, as it is defined by the President. And as national problems grow in number and urgency, the act of voluntary concurrence in the national interest must come more often. Indeed, this willing concurrence is necessary if the *national mood* is to merge with the national responsibility, especially in the field of foreign relations.

Much has been said about America's need to *identify its interests* with those of the changing societies of Asia, Africa, and Latin America. This is, as suggested, a very serious matter. One of the best comments, I think, was that made last year by the distinguished essayist, Mr. E. B. White. He wrote:

> Speaking of engaging men's minds, this is another thing we seem willing to leave to the Russians. The figures on it are appalling. The authors that are circulated most widely today, in translation, are Marx, Lenin, and Stalin. Between 1948 and 1955, Lenin ran ahead of the Bible. I don't know where he stands today in relation to the Bible—he may have slipped a little—but I know where he stands today in relation to John Adams, James Madison, Benjamin Franklin, Thomas Jefferson, and some of the other writers we like to think are stimulating to readers. He is out in front by a commanding lead—one that will be hard to overcome. We in America have no right even to brood about the unity of free men unless we are energetic enough to make our ideas available to those who are desperately seeking any idea at all. The Army fired a missile the other day and hit a target nine thousand miles away, but we've put very little time or money into launching our best missile—our *ideas*. We should flood the world with the good books that make men's hearts catch fire. We should not expect the man in the antipodes to travel to the corner of Forty-second Street and Fifth Avenue and search through the card catalogue.

This is eloquent and compelling advice. It must be acknowledged. But how are we to engage the minds of others if we are unable to *engage* the *minds* of our own citizens? This, I think, is *the* problem of surpassing urgency. If we are not revealing our ideals and purposes through our greatest political philosophers, then we must do so through our political leaders and others who are obliged to serve the national interest.

In the President, we have an articulate and vigorous advocate of the national interest and of the national responsibility. For that, I am very grateful. Yet, as I suggested earlier, the programs of a President under our system are as strong and responsive as the people themselves are strong and responsive. And it is the task of those others of us who are obliged to serve the general interest to speak out in informed and thoughtful terms on the problems that are truly *national*—those which lie with equal weight on all regions of the country and all sectors of the society. In doing so, we will necessarily be competing with an *infinity of special interests*—and with the so-called public opinion manipulators, who represent not only domestic clients of every description, but foreign governments as well. The total of effort and investment devoted to opinion-manipulating, or molding, in this country now represents one of the major undertakings. It pervades our national life. Books on the subject are found on the best-seller lists. Many newspapers and radio stations accept uncritically the handouts given them by the opinion-makers. Motion-picture houses offer short subjects, as well as newsreels, which frequently contain material created and donated by these image-makers, and in their concern with narrow interests, they have helped to blur the national interest, and hence the national style as well. And they have had a disturbingly compliant, unskeptical society to work with.

It is plain that since the Korean War days, Americans have suffered what in athletic circles is known as a *let-down*. Since then, individual

prosperity in our country has risen, by and large, while the nation itself has been diminished, in terms of both prestige and relative strength. We have created the richest society in the material sense that the world has seen. We are more than merely affluent. We are the acquisitive society. Our consumption is staggering. We have at our disposal a kaleidoscopic array of things to buy. There is irony in this, but little that can be rationalized into optimisim, because it is doubtful that the old, empirical attitudes that have accompanied this affluence are relevant to our present role as defenders of western civilization.

There is nothing new, or radical, in what I am saying. As early as 1897, a far-seeing man, Mr. Theodore Roosevelt, said:

> . . . If we lose the virile, manly qualities, and sink into a nation of bucksters, putting gain above national honor, and subordinating everything to ease of life, then we shall indeed reach a condition worse than that of ancient civilizations in the years of their decay.

The decay in our civilization is pervasive—visible to anyone who can look above his private interests and preoccupations. It is visible in institutions, such as labor unions and large business corporations. Recently, we had a glimpse of how the free-enterprise system, of which we speak so proudly, can be manipulated and stultified by corporate executives, who, among other things, are not above conspiring to violate the law and to gouge the public. How foolish we look to others when we officially extol private enterprise and our greatest corporations betray it.

The decay is more than moral. As much as anything, it appears to be a spreading decline in taste and in a sense of values. To take one example, the American bemusement by size has become, if anything, more conspicuous. Santayana pointed to our "singular preoccupation with quantity." And Tyrone Guthrie, according to a recent article in the *New Yorker*, has noted our easy assumption "that a big country, a big building, or a big potato is not just bigger than a small one; that there is inherent virtue in jumbo size."

To me, the irony of this involvement with size, as I observed earlier, is the unwillingness or inability of so many Americans to identify themselves with something as vast as the United States. Bigger cars, bigger parking lots, bigger corporate structures, bigger farms, bigger drug stores, bigger supermarkets, bigger motion-picture screens. The tangible and the functional expand, while the intangible and the beautiful shrink. Left to wither is the national purpose, national educational needs, literature and theater, our critical faculties. The national dialogue is gradually being lost in a froth of misleading self-congratulation and cliché. National needs and interests are slowly being submerged by the national preoccupation with the irrelevant.

We Americans are justly proud of our country. Our experience as a nation, although brief, has been rich in accomplishment and admirable in purpose. Yet our society is becoming corrupted by its submission to the irrelevant; by payola, for example, in its infinite variety; by indulgent tax laws and ludicrous expense accounts; by the willingness of Americans to substitute the absurd for the beautiful.

Our cities are an example. With a few notable exceptions they become steadily larger, but steadily less beautiful and less inhabitable as well. Some years ago, *Fortune Magazine* observed that America's large cities were becoming inhabited by "the very rich, the very poor and the slightly odd." The rest are taking refuge in the suburbs. Apart from the corrosive effects of this migration on our steadily shrinking countryside, the large cities are being deprived of their best and most vigorous people. And the schools, political processes, architecture, skyline, monuments, and other elements of life in these cities, are abandoned to a gradual but steady deterioration.

It may be that the accelerating deficiencies in American life were inevitable. Americans are a ruggedly positivist and determinist people. We have shaped an environment to our will. Our concern with cause and effect—with the palpable, the negotiable and the functional—stimulated enormous growth in the first century, or so, of our history. This growth has materialized into what we call the American way of life, with its implicit offer to every citizen of a life not only *free from want*, but even more bountiful.

Preoccupied with this way of life, Americans have failed to develop a philosophical and cultural base to sustain it. This is the more perplexing when we consider the rich cultural and philosophical heritage that we possess, along with the strong cultural influences to which we have been exposed. We often complain that we are misunderstood and unappreciated abroad. The problem, to a considerable extent, lies with our terms of reference. They do not faithfully reflect our heritage, the principles and ideals that we profess.

The United States is clearly undergoing the gravest test of its history. Yet around the country there is apathy and unconcern, according to those who sample the national mood. Not long ago, an influential newspaper editor compared the American attitude to its current external difficulties with what he called the "earthquake in Afghanistan problem." He made the point that troubles in Afghanistan, for example, do not concern his readers, only troubles at home. Afghanistan is too remote to be a source of concern.

Yet the United States may have become the protagonist for man's last hope of a way of life that is consonant with his highest purposes. A good part of the world anxiously thinks so. Thus, the world expects more from the United States and its citizens than from other governments and other mortals. Our mistakes and our deficiencies are exaggerated by our friends as well as our enemies. And this, coupled with a lack of full appreciation of our virtues by others, disturbs Americans. But curiously enough, it does induce them, at least momentarily, to think of themselves as Americans, not as Texans, or Rotarians, or glass workers, or farmers, or doctors.

It does not, however, induce self-examination, which I fear is what the situation may really demand of our society. A nation that rather aggressively prefers parking lots to parks is probably not ready for that inward look. A people engaged in self-impoverishment cannot be expected to become self-critical until the scales have tipped *decisively*, and the need to restore a healthy balance is perhaps dramatically made clear. In short, it may be that only a *catastrophe*—at the least, a national crisis obvious to all—will bring the country into harmony with its responsibilities.

That is a pessimistic evaluation. Perhaps it is too bleak. In any case, I do not pretend to have the answer to the problem of preparing our society for the difficult and taxing days ahead. But I would fully subscribe to the tone of the President's inaugural address. "Ask *not* what the country can do for you, but what you can do for your country." This electric phrase may have touched the American conscience. The reaction to the Peace Corps is interesting, and should probably offer some encouragement. In Washington, many people believe that the Peace Corps concept is aimed not so much at the needs of less-developed countries, as at the need to generate enthusiasm among Americans for their own responsibilities. The ultimate contribution of the Peace Corps to its stated objectives may be relatively small, even negligible; but, as a device to dramatize certain problems and bring a sense of idealism and purpose to these problems, it may have significant effect.

I wish I could say that the burden of the new administration's program was in line with the tone of the President's possibly historic first statement. It is not, though, and of necessity probably could not be. Nevertheless, in Washington at least, there is an impression that strong leadership and direction have been returned to the conduct of our affairs. And this, I think, is the first step toward the goal of developing a national appreciation of this country's true position and function in the society of nations.

I return to the thought with which I began that the leadership of the President, of any President, is not enough in the democratic, pluralistic society which we have created on this continent. His leadership can be effective only if he is able to bring about, with the help of all of us, a consensus among our people. Since we are not an authoritarian society, this can be accomplished only by an unparalleled effort on the part of everyone, to understand and to work as never before, for the restoration of an appreciation of quality, of beauty, of intelligence and integrity in our national sense of values.

These purposes may be pursued by all of us without reference to any foreign power, friendly or unfriendly. Our failure to pursue them may not be attributed to anyone but ourselves.

As Erasmus put it, only by "the good influence of our conduct may we bring salvation in human affairs; or like a fatal comet we may bring destruction in our train."

THE KINGDOM OF CORSICA AND THE SCIENCE OF HISTORY

ROBERT R. PALMER

Professor of History, Princeton University

(*Read April 21, 1961*)

THE Kingdom of Corsica was an ephemeral organization, a by-product of the wars of the French Revolution, lasting only two years, from 1794 to 1796, and then forgotten, even by history. Today it would be an unusual expert who had even heard its name. Recently in the Rare Book Room of the Princeton University Library I came upon some documents of this vanished kingdom.[1] They are mostly laws, decrees, and speeches. Although published at the time, they are now so rare that of fifty at Princeton only eleven are at the British Museum. The subject seemed sufficiently obscure, minute, intriguing, and in its way technical to be suitable for the present occasion, and at the same time to lend itself to broader reflections of a philosophical character. What a historian does with a small episode may be of interest to an audience specialized in other fields.

Some of us lately have tried to see the period of the French Revolution in a broader perspective, as a time of revolutionary disturbance, or struggle between forces that may be labeled as democratic and aristocratic, afflicting Western Civilization as a whole. I shall fit Corsica into this larger design. Let me remark also in passing, to put the present audience in the mood of the paper, that the American Philosophical Society was not uninvolved in this revolution of Western Civilization. At least five of our members died in the French Revolution, four of them on the guillotine, the most famous being Lavoisier and Condorcet. The foreign membership in the 1790's included a good many who were then called "Jacobins"—various Frenchmen, two Poles, an Italian, and half a dozen Englishmen, of whom two were members of the House of Lords. In 1797 our Society chose the most famous of American "Jacobins," Thomas Jefferson, as its president.

Corsica is an ethnically Italian island which has belonged to France since 1768, except for the two years of the Kingdom. In the eighteenth century it still showed the effects of isolation. Primitive, picturesque, and poor, a land of superb views over the Mediterranean, of craggy mountains, fast clear rivers and sub-tropical vegetation, it was a country unused to organized government, peopled by excitable villagers who carried guns in their daily affairs, and made a virtue of clannish loyalties and immemorial vendettas. The island had attracted the notice of various writers; both Rousseau and James Boswell had praised its spirit of liberty, and the patriot Paoli, in the 1760's, became sufficiently world famous to have a place twenty miles west of Philadelphia named in his honor.

After 1768 Corsica entered upon a process of assimilation to the institutions of France, at first under the monarchy, then during the Revolution, which offered to the Corsicans, or imposed upon them, exactly the same rights, liberties, and obligations as to the citizens of mainland France. In the mid-century there had been a strange German adventurer who for a while had enjoyed the title of King Theodore of Corsica. His son still lived in England, and in 1795 published a book, which, though dutifully dedicated to King George, actually gave the impression that the Corsicans had already developed strong ties with France, and were well disposed toward the initial developments of the French Revolution.[2]

[1] The volume, which has no title page, is catalogued as EX 1513.368.26 by the Princeton University Library, and includes 59 printed items of which a few are duplicates. For further bibliography see C. Starace, *Bibliografia della Corsica*, 503–512, Milan, 1943. The chief printed sources are *The life and letters of Sir Gilbert Elliot first Earl of Minto, . . . edited by his grandniece the Countess of Minto* 2: 211–380, London, 1874, and various materials published by the Société des sciences historiques et naturelles de la Corse in its *Bulletin* for 1892–1896, 1899, 1920 and 1922. Some of the important documents were published in English in the *Annual Register for 1794*, London, 1799. The only full historical study is by M. Jollivet, *Les Anglais dans la Mediterranee 1794–97: Un royaume anglo-corse*, Paris, 1896.

[2] *The description of Corsica, with an account of its union to the crown of Great Britain, including the life*

But Corsica, like France, was soon divided among counter-revolutionaries, moderate revolutionaries and radical revolutionaries. Among Corsican families favorable to the new order the most famous in later years were the Bonapartes. The aging Paoli, now approaching seventy, became the rallying point for the anti-French and anti-Revolutionary party.

For Paoli and his followers the outlook brightened when the British fleet, in 1793, occupied the French city and naval base at Toulon. It was widely believed that the French Republic was expiring in a convulsion of anarchy and bloodshed. Paoli made overtures to Francis Drake, the British agent at Genoa. If Corsica could be taken over by the English, he wrote, then "its form of government can be arranged, so far as possible, in a way analogous to that of Great Britain."[3] He suggested Ireland as the model of a semi-autonomous kingdom under the British crown. When the British shortly thereafter were forced to evacuate Toulon, they accepted this Corsican offer. Against some resistance by both Corsicans and French, the British fleet and army installed themselves in the island, along with a civilian administrator, Sir Gilbert Elliot.

The issue was primarily military. The British at the moment had no Mediterranean base east of Gibralter. They had held Minorca for seventy years, but had lost it in the War of American Independence. They did not occupy Malta until 1800. Corsica, not yet really French, might prove a useful permanent acquisition for Great Britain. More immediately, it had a high strategic value in Sir Gilbert Elliot's eyes. Driven from Toulon, the British might continue from Corsica to blockade the southern French coast, support the French royalists in France, maintain internal resistance against the Paris government, and create a league of Italian states in alliance with Britain and Austria.

But the war was also what would now be called ideological. This does not necessarily mean that either party, either revolutionary France on the one hand, or Britain and other powers of the Coalition on the other, carried on the war for the purpose of spreading its own ideas. It does mean that each belligerent took advantage of discontents within enemy states, and that, if in the course of hostilities it occupied foreign territory, it found sympathizers among the local population, and proceeded to organize public authority according to its own principles, and through the medium of its own adherents. In 1794, the year of the British occupation of Corsica, the French began to go on the military offensive, reaching Holland at the end of that year, north Italy in 1796, Rome and south Italy and Switzerland in 1798 and 1799. As with the British in Corsica, the French could in each case show some kind of "invitation," more or less genuine and significant, although in each case it was the needs and fortunes of war that determined the outcome. The point is that where the French went they called into being revolutionary republics, while the British reorganized Corsica as a monarchy. Thanks to the French, various local elements created the Batavian Republic in the Dutch Netherlands in 1795, and the Cisalpine and other republics in Italy after 1796. Thanks to the British, various local elements set up the Kingdom of Corsica in 1794.

The significance of the Kingdom of Corsica, therefore, is this: it is a piece of evidence to show what was at stake in the ideological struggle of the French Revolutionary wars, revealing what happened where conservative forces triumphed, and suggesting what might have happened if counter-revolution had prevailed at this time in France itself. It provides this evidence, so to speak, under the most favorable conditions. We know what happened in Poland when counter-revolution prevailed there in the second and third partitions. We know what happened in Italy during the brief Austro-Russian reaction of 1799. Britain was different; though conservative it was not wholly illiberal, and Sir Gilbert Elliot was of the highest type of British public servant, honest, capable, experienced and genuinely concerned with the welfare of the people put in his charge. He was later, as Earl of Minto, to be Governor-General of India. He came to Corsica convinced that the Corsicans had unanimously appealed for British aid, a view which, if it showed the limitations of social outlook of the British aristocrat, allowed him to act with undiminished integrity. He liked the Corsicans; he thought that, if the island was a little uncivilized, it was no more so than the Scottish border a few generations before, and there were local leaders who

of General Paoli and the memorial presented to the National Assembly of France upon the forests in that island . . . illustrated with a map of Corsica, dedicated to His Majesty, by Frederick, son of the late Theodore, King of Corsica, London, 1795. The volume is in the American Philosophical Society Library.

[3] Paoli's letter is printed in the documentary appendix to the *Cambridge history of British foreign policy* **1**: 553, New York, 1922.

seemed to him, in his own words, like remarkably good specimens of a country gentleman in England or Scotland. He read Dante with some of them, and talked philosophy with others.

Hardly had the British arrived when a general election was held, which produced an assembly, which in turn adopted a constitution, declared the country a constitutional monarchy, and offered the crown to King George III. The crown was accepted, and Sir Gilbert Elliot became Viceroy of Corsica. There were jokes in the Paris newspapers about King George's new kingdom, but in Corsica and England it was taken seriously enough; the Viceroy assured the Corsicans of the "august virtues" of their new monarch, who "has ever governed according to the laws"; and at Westminster, at the opening of Parliament at the end of the year, a very bad year for the anti-French coalition, the ministers who composed the king's speech could think of only two things to boast of—the Jay treaty with the United States, and the acquisition of the crown of Corsica.[4]

Let us examine first the constitution of Corsica, then the legislation enacted under it. The purpose,[5] as stated by the Corsicans now in power, was to protect "liberty and religion" against "the tyrannical anarchy of the present republic of France."[5] The new constitution was intended to resemble that of England. A Parliament was created, with that name. Legislative power rested in King and Parliament together; that is, the Viceroy had a veto, and laws were enacted, following the British formula, "by the king's most excellent Majesty." Each country district or coastal town sent two members to Parliament, as in England. Men could vote who were at least twenty-five years old, and possessed of landed property. To be elected to Parliament, however, the qualifications were rather high; an annual landed revenue of 6,000 lire was required, the equivalent of some £200 sterling. Here again the parallel to England was striking. Members of Parliament served without compensation, as in England. Since persons resembling lords could not be found in Corsica, the Parliament had only a single house. To protect religion, however, the Catholic bishops sat as members of Parliament, like Anglican bishops in the English or Irish House of Lords. Executive power lay with the Viceroy. Courts were instituted, trial by jury was provided for, and various civil rights were promised. Roman Catholicism was declared the national religion, with toleration for others.

We may profitably contrast this Corsican constitution of 1794, modeled on the British, with the constitution of the Cisalpine Republic of 1797, modeled on the French, applied in Lombardy, and embodying the ideas of the European revolution.[6] The Cisalpine constitution proclaimed the sovereignty of the people. There was no independent executive; the executive was chosen by the assembly, itself elected by voters in proportion to population. The Cisalpine constitution looked to separation of church and state; it was not anti-Catholic, but it put no bishops in positions of government. The suffrage in the Cisalpine Republic was hardly more democratic than in the Kingdom of Corsica. The difference lay elsewhere. It is illustrated in the figure of 6,000 lire, which occurs in both constitutions.[7] In the Cisalpine Republic, deputies were to receive an annual salary of this amount. In Corsica, they received no salary, and were required to have an income of this amount from their own property. The Cisalpine Republic embodied the democratic formula that public officers were wage-servants of the people. The Corsican kingdom followed the principle that government should properly be conducted by an upper class enjoying an independent income from land.

The regime set up under this constitution soon came to represent a cross section of the forces arrayed against French republicanism, briefly gathered in a kind of happy isle of the European Counter-revolution. Sir Gilbert Elliot took steps to live in a state suitable to a Viceroy, making arrangements for a salary of £8,000, which fortunately for the Corsicans was to be paid from British funds, since it was almost half as large as the whole proceeds of taxation in Corsica. As an indication of a trend, it may be remarked that the last British governor of Virginia, which was wealthier and more populous than Corsica, had received less than half as much; and that the first British governor in South Africa, the Earl of McCartney, occupying Cape Town in 1795, re-

[4] *Moniteur universel*, October 18, 1794; Elliot's speech to the Corsicans as printed in *Annual Register for 1794*, 111; *Parliamentary history* 31: 960, Dec. 30, 1794.

[5] *Annual Register for 1794*, 101–102; the English text of the constitution is here, *ibid.*, 103–109; the Italian text is in A. Aquarone *et al.*, *Le costituzioni italiane*, 715–720, Milan, 1958.

[6] For the Cisalpine constitution see Aquarone, *Costituzioni italiane*, 87–120.

[7] In the Corsican, Title II, art. 3; in the Cisalpine, Title V, art. 68.

ceived a salary of £10,000, a sum half as large as the total revenue of the Cape Colony.[8] Elliot's £8,000 was the equivalent of over 30,000 eighteenth-century dollars, and so would correspond to two or three hundred thousand dollars today. Enough of such sordid details. Lady Elliot with her younger children soon came out to join her husband in his Mediterranean sojourn. They talked much of England, and of their boys preparing for Eton College. Family life and social life at the Viceroy's palace became very agreeable.

As his administrative secretary, the Viceroy chose Frederick North, a remarkable linguist with a good knowledge of Italian, who, so far as his social origins were concerned, was the third son of the Lord North of the American Revolution, and hence in later years became the fifth Earl of Guilford. Positions as Anglican chaplain, and as aides to the Viceroy, gave employment to other suitable young men from England. There were also British officers from the garrison and from the fleet, including the future Lord Nelson. And there were French émigré noblemen, unfortunate refugees from the Revolution, who had lost their property after their emigration, and who now sought service with the British in the hope of winning back their former position in France. As Lady Elliot wrote to a friend in England, "We have dukes and princes as ensigns and lieutenants who once enjoyed their £10,000 or £15,000 a year."[9]

The Viceroy had more trouble with some of his Corsican associates. Paoli was crotchety, suspicious, impossible to cooperate with, and unable to accept anyone as his superior or even as his equal in the conduct of Corsican affairs. His relations with Sir Gilbert Elliot were a series of comical misunderstandings. On one occasion, when a bust of him was moved and its nose chipped by accident, he was enraged at the supposed insult. On another, when it was agreed that, to pacify him, a miniature portrait of King George, set with diamonds, should be sent to him from England, and when in fact for some reason the portrait was not sent, he was again indignant and accused the Viceroy of stealing the diamonds. Sir Gilbert and Lady Elliot were astonished that anyone could believe such a thing of English people like themselves. Paoli was finally persuaded to retire to England.

In effect, the Corsican prime minister under the Viceroy was Pozzo di Borgo. Descended from an ancient Corsican landowning family, he was at this time a young man of thirty, just entering upon a long career of half a century of opposition to the France of the Revolution. Twenty years later, in 1814, upon the defeat of Napoleon, he was to ride victoriously into Paris in the train of the Russian Tsar.

Such were the more prominent of the persons now active in the Kingdom of Corsica, unless one wishes also to add the Pope, who began to demand an influence in the island which both the French monarchy and the French Revolution had denied him, and which the Protestant Viceroy dismissed as an intrigue. Without futher research, it is hardly possible to say who the less prominent supporters of the regime were. Probably Sir Gilbert Elliot's diagnosis was correct. Everything depended, he reported, on how the bulk of the Corsican people read the future. If they thought that the British would certainly stay, they would accept them; if they thought that the British were in the island only temporarily, they would be unwilling or afraid to commit themselves.

Meanwhile, in the governing circles there was a pleasant interlude, charmingly described for us in Lady Elliot's letters. They are the letters of a perceptive, capable, and much favored woman, who was at first enchanted by the island and its people. She was attracted by their vivacity and good humor, though a little disconcerted by their habit of carrying arms. She took trips to visit old convents, or explore mountain trails, or see the almond trees in bloom. There were outings and excursions and receptions, and even a

[8] Jollivet, *op. cit.*, 65–66 n., quotes an exchange of letters between Elliot and the Duke of Portland (not included in Elliot's published correspondence), in which Elliot proposed £10,000 plus £3,000 for expenses, but was granted only £8,000 with £2,000 for expenses. The Corsican budget for 1795 is set forth in the *Discorso del signor Mario Giuseppe Peraldi. . . . nella sessione de 13 Maggio 1795*, included in the later middle part of the volume at Princeton mentioned in note 1. The budget provided for a revenue of 601,000 lire; since the Corsican lira was apparently worth eight pence (*Encyclopedia Britannica*, third edition [1797], art. "Money"), £8,000 would represent some 240,000 lire. For the Earl of McCartney's salary at the Cape at the same time, see G. E. Cory, *Rise of South Africa* 1: 76, London, 1910, and G. M. Theal, *History of South Africa* 1: 29, London, 1910. The pre-revolutionary governor of Virginia received £2,000 plus perquisites for a total income of about £4,000 (P. S. Flippin, *Royal government in Virginia*, 77, 80; the royal governor of New Jersey received £1,000 plus £60 house rent (Kemmerer, *Path to freedom: the struggle for self-government in New Jersey*, 157).

[9] *Letters of Sir Gilbert Elliot* 2: 338.

viceregal ball, attended by the Corsican notables, the British officers, and the French noblemen.

The legislation enacted by the Viceroy and Parliament was of course designed for the benefit of the country as understood by those who now governed it.[10] Some of it suggests the less gentle features of British law at the time. Criminal law was severe, with burglary punishable by fifteen years in the galleys, except that theft by domestic servants or others having habitual access to a house was punished by fifteen years, and the stealing of sacred objects in church, by twenty, in the galleys. There was also the war to carry on, and France to be defeated; the British Mediterranean fleet was short 2,000 men, and Corsican seamen became subject to impressment into the Royal Navy.

Some legislation was in the strict sense simply reactionary, undoing what had been done during the Revolution. Property confiscated from the church was returned to it, though with provision for compensation to the new owners. Church tithes were reimposed. Violence against the Catholic religion was made punishable by death. The Revolutionary legislation against primogeniture and entails (*Fidecommessi*) was repealed. The Revolutionary principle of removing education from church control was repudiated; a university and secondary schools were to be set up, subject to inspection by the bishops. The salt tax of the late French monarchy was restored; it was now to be much heavier than before 1789, since the new regime showed a preference for indirect taxation.[11]

Other enactments were political, intended to protect the persons now in power from those who might overthrow them. Here the Viceroy tried to exercise restraint. He conceived of himself as a reasonable Englishman among temperamental Latins, and he repeatedly advised against vengefulness. He underestimated the internal discord within the country. He could not believe that respectable Corsicans opposed the new order, since he never met any such people. He tried to learn, and made tours about the island, but he was hardly in a position to be in close touch with the full range of opinion.

Resistance against the Anglo-Corsican kingdom soon developed an indigenous republican underground, committed to the overthrow of the regime and to ending the union with England. So far as Corsica had any professional or business people, they seem to have tended, as in all countries including Britain itself, to have looked with favor on the French Revolution. Of five leaders of the underground whose names are known, three were doctors.[12] The gentry also proved increasingly disappointing to Sir Gilbert. Where at first he had seen "remarkably good specimens" of a country gentleman, he found them, a year later, not "beyond the pitch of a good yeoman in England, or of the humblest squires of our remote counties."[13] The basis of a social and political system like that of England seemed to be lacking.

The French also sent in secret agents, one of whom submitted a long report to the Directory in August, 1796. As a spy he was harmless, and his report was mere hearsay, since after elaborate preparations he got no further than Sardinia, where he was stricken by fever, and where all he could manage, in discharging his mission, was to have a series of confidential conversations with a visiting Corsican merchant. He reported that insurrections against Pozzo di Borgo and the British had begun months before, and that two-thirds of the people favored France, but would not take the risk of open rebellion until a French army invaded.[14]

Threatened with subversion, and despite the Viceroy's pleas for moderation, the Corsican Parliament behaved like the French Convention during the Terror. At least the legislation was much the same. There were laws against traitors and émigrés. There was a law taking their property from them, and promising it to those who had sustained losses in the late disturbances.[15] There was a law prescribing death to

[10] For this and the following paragraphs see the volume at Princeton; also Jollivet, *op. cit.*, 97 ff.

[11] The salt tax prescribed in the budget mentioned in note 8 above was to bring in 170,000 lire; the salt tax before 1789 had produced 46,752 livres, according to a committee in the Constituent Assembly in 1791, which had no reason to understate the taxation of the Old Regime (*Archives parlementaires*, 26, the tables following p. 532). The French livre was apparently a little more valuable than the Corsican lira.

[12] Jollivet, *op. cit.*, 245.

[13] *Letters* 2: 258 and 306.

[14] "Le consul de la République française à Majorque au Ministère des Affaires étrangères," 10 fructidor An IV, in Archives des Affaires étrangères, Mémoires et Documents, Provinces françaises, Corse, vol. 1538, folios 345–356. The report is by one Angelucci, a French citizen and consul at Majorca, directed in the spring of 1796 to make a secret trip to Corsica.

[15] The very language is an amusing mixture of British parliamentary and French revolutionary phraseology: "George III King of Great Britain, Ireland, France and Corsica: Act of Parliament of 18 May 1795. . . . Considering that nothing is more worthy of the humanity of

émigrés if they returned, and another decreed death for correspondence with the enemies of Corsica and Great Britain. Another required priests to take an oath to the constitution. There was a law forbidding unauthorized public assemblies, as well as spontaneously formed crowds or *attrupamenti*. Another suspended jury trials, and another offered a reward of 5,000 francs for every secret republican emissary from France that could be apprehended.

Constitution or no constitution, freedom of speech disappeared. In August, 1796, the administrative secretary, Frederick North, sent instructions to C. B. Buttafoco, the King's attorney at Bastia. It should be remembered that only a few months before, in England itself, Parliament had curbed political discussion by the Seditious Meetings and Treasonable Practices Acts. It is necessary, said North to Buttafoco, to stamp out all signs of the *maladetto republicanismo francese*.

> It will be a great advantage to persuade all the most notable patriots [a word used by all parties] to prevent by cómmon accord political discussion of any kind; but if this proves impossible, and if republicanism shows itself in any way, then it will be necessary to arouse to the utmost the patriotism of the well-affected against the guilty, and to put these persons under arrest.[16]

In short, a regime ostensibly conservative adopted the features of the radicalism it denounced. The counter-revolution became the mirror image of the revolution itself. It was not only Robespierre's "republic of virtue" that pursued the "guilty." Moderation failed. Choices were limited. One might choose between monarchy and republicanism, but there was no real choice between revolution and a peaceful rule of law, or between revolution and a calm and orderly conservatism.

In any case Corsica soón became untenable by the British. When the Corsican-born French republican general, Napoleon Bonaparte, launched into his sensational campaign in north Italy, excitement in the island got beyond control. The French occupied Leghorn, threatening to invade; for preliminary propaganda, they found a Leghorn Jewish merchant who translated into Italian a certain work on the imminent collapse of British finances, written by a member of the American Philosophical Society, Thomas Paine.[17] The British evacuated, and their chief Corsican supporters became émigrés in their turn. That was the end of the Kingdom of Corsica. It is ironical to be able to add that the British cabinet, a few weeks later, decided to offer the island to the Empress of Russia. King George expressed an especial personal satisfaction at this solution, which was never in fact carried out.[18]

Time is lacking to explore the "science of history," as promised in my title, which was meant to be somewhat enigmatic. In a sense there never really was any Kingdom of Corsica, and there is no science of history. The point lies in the connection between these two negations. The Kingdom of Corsica was a might-have-been, an attempt that failed. But the historian must take account of might-have-beens. He deals with the potential as well as the actual. He must show not only what happened, but what might have happened. This does not seem very scientific, though it has been given a technical name, "the retrospective calculation of probabilities,"[19] by which the historian, looking back, tries to reconstruct the various apparent alternatives as seen by living men at a given moment. It is the beginning of historical wisdom to realize that all events, like life itself, take place only in present time, their pastness reflecting only the human limitation of the observer. The historian who confines himself literally to what happened will produce a dry and lifeless recital. Life enters when the "if's" and possibilities and might-have-beens are also suggested.

The Kingdom of Corsica, however ephemeral, remains a revealing phenomenon. First, we take

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the national justice than to grant relief to those communities and citizens that have suffered misfortunes in fighting for the liberty and independence of their country.

May it please the King's most Excellent Majesty, with the consent of the House of Parliament assembled in this present session, and by the authority of the same, to enact and be it enacted as follows:

I. Relief shall be granted to the inhabitants of the communities of. . . .

II. This relief shall be taken from the property of Traitors to their Country. . . ."

The document is at about the first quarter of the way through the Princeton volume.

[16] M. A. Ambrosi-R., ed., gouvernement anglo-corse: Correspondance du Secretaire d'Etat, Frédéric North avec les autorités administratives de la Corse, *Bulletin de la Société des sciences historiques et naturelles de la Corse* **42**: 191, 1922.

[17] J. Godechot, *Les commissaires aux armées sous le Directoire* **1**:464 n, Paris, 1938.

[18] Great Britain: Historical Manuscripts Commission, *The manuscripts of J. B. Fortescue preserved at Dropmore* **3**: 261, London, 1892–1927.

[19] Raymond Aron, *Introduction à la philosophie de l'histoire: essai sur les limites de l'objectivité historique*, 165, Paris, 1948.

it to be typical of the European counter-revolution. Though reasonably certain, this affirmation is not demonstrable statistically. We use the type-case to illustrate what might have happened if the Counter-revolution had been successful, and to realize thereby the significance of the Revolution itself. We see what the Revolution was against. It becomes clear that the Revolution was not against the Old Regime, strictly speaking, since no present time can really be locked in combat with its past; it was against a very present effort to restore or strengthen certain features of the Old Regime, a very different thing from the Old Regime itself. Observing the Revolution and the Counter-revolution alongside each other, we find them alike in some ways, as in violence, suspicion, expropriation or persecution. We can morally disapprove of these things without allowing our political judgment to be unduly swayed. We then see the differences between the Revolution and the Counter-revolution in their aims or ideals, or in the kinds of persons and institutions that they respectively brought forward, or in the consequences which the prevalence of the one or the other would probably entail. To understand either, it is necessary to know the other. We recapture also the living present in which men worked, with all its uncertainty, its effort, exertion, tension, conflict, fear, hope and need of action while remaining ignorant of the future. A history that does this is not science, but it is none the less something to think about.

THE GENEVA FOLIO REPRINTING OF THE *ENCYCLOPÉDIE*

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In earlier studies I have discussed the publication of the several Swiss folio, quarto, and octavo editions of the *Encyclopédie*, using as sources materials from contemporary journals, correspondence, and works of reference.[1] The purpose of the present study is to throw additional light on the Geneva folio reimpression of 1772–1776, based on data from the manuscript records of the Geneva state archives, especially the official records of notaries J. J. Dunant and Mercier, the minutes of the Venerable Company of Pastors and the Magnificent Council of Geneva, and from the Correspondance de Charles-Joseph Panckoucke in the Bibliothèque Publique et Universitaire of Geneva.

As is generally known, the twenty-eight volume folio *Encyclopédie*, published from 1751 through 1772, was the outcome of a plan orginally conceived for the publication of a French translation of Chambers' *Cyclopaedia or Universal Dictionary of Arts and Sciences*. After several false starts the prime mover in the enterprise, the Parisian bookseller and printer Le Breton, with his associates Briasson, Durand, and David, turned to Denis Diderot. By this time a much more ambitious undertaking was in view, which, carried further by editor Diderot and his collaborators, resulted in a new and in many respects original work, presenting (1) an outline of human knowledge, with stress on the importance of the mechanic arts, and (2) an exposure of prejudice and superstition. With the aid of many scholars, and especially the brilliant mathematician d'Alembert, Diderot brought out the first volume in 1751. From then until 1765, when the last ten volumes of text appeared, the task encountered frequent delays, suppression by the authorities, condemnation by Rome, the defection of some of the co-workers, including d'Alembert, the mutilation of many of Diderot's articles by Le Breton, and repeated attacks by the clergy.

[1] Watts, George B., The Swiss editions of the *Encyclopédie*, *Harvard Library Bulletin* **9**: 213-233, 1955; The *Supplément* and the *Table analytique et raisonnée* of the *Encyclopédie*, *French Review* **28**: 4-19, 1954.

The records of notary J. J. Dunant for the period January 12, 1770, to January 29, 1771, are especially significant, for they give not only the details of the contract drawn up in his office on June 26, 1770, between Charles-Joseph Panckoucke of Paris and Gabriel Cramer and Samuel De Tournes of Geneva for the printing in Geneva of 2,200 folio sets of the *Encyclopédie*, but also of the two earlier contracts whereby Panckoucke came into possession of the rights and plates of the original Paris folio edition.

On page 1305 of the Dunant records there is a copy of the agreement between Le Breton, Briasson, and David, parties of the first part, and Panckoucke, Jacques Chauchat, and De Saint, parties of the second part, of December 16, 1768, by which the original owners "sold, yielded and delivered for all time" all rights in any future reprinting of the *Encyclopédie*, and also all the copper plates, "which are engraved . . . as well as those which remain to be published." The new owners agreed to pay Le Breton 111,111 livres, two sous, and two and two-thirds deniers, and Briasson and David 44,444 livres, eight sous, and ten and two-thirds deniers each, over a period of six years, beginning in January, 1771. Panckoucke and his partners, who could begin their edition in July, 1769, were to guard "the most complete secrecy as long as possible." The first installment was to consist of the first three volumes of text and one of plates. A public subscription, on the same terms as the original edition—504 livres for the seventeen volumes of text and 290 for the plates—could not be advertised before July, 1770. Some 250 or 300 still undelivered volumes of the original edition were sold to the new owners at a twenty per cent reduction. Panckoucke and his associates agreed to pay one thousand "louis d'or neufs" if they failed to keep their agreement, and the sellers were to pay a like sum if they printed more than four thousand copies of a *Supplément* which they were planning to publish.

As I have already pointed out in the *Harvard Library Bulletin* and the *French Review*, Panc-

koucke, who, by agreements of July 1, 1769, and May 25, 1770, with De Saint and Chauchat—details of which may be seen in the Dunant records, (p. 1289 and p. 1305)—became sole owner of all rights to the reprinting, had originally planned to publish a completely revised edition. Because of governmental opposition, however, this scheme was abandoned in favor of a simple reprinting of the first, which was to be fortified with a *Supplément*. Printing began in 1769, and three volumes of text were ready for the market by February of the following year, when the French government halted the publication and caused all copies of the first three volumes, except for some thirty or forty sheets, totaling some four thousand, to be seized and immured in the Bastille.

Further publication in Paris being impossible, Panckoucke turned to the famous printer of Geneva, Gabriel Cramer, with whom he had been in correspondence since May, 1769, concerning a proposed edition of Voltaire's verse, and the Yverdon quarto edition of the *Encyclopédie*, which Fortuné-Barthélemy de Félice had conceived in 1768. By the end of March, 1770, Panckoucke had become, according to Voltaire, an "associate" of Cramer, and was soon making plans for a visit to Geneva. On April 12, d'Alembert informed Voltaire of Panckoucke's coming, and, on June 8, wrote that he had assured him that Voltaire would not refuse his "kindnesses" and "counsels."[2]

Although complete details are lacking, it is clear that Panckoucke had previously enlisted the cooperation of other printers and entrepreneurs before making a definite agreement with Cramer and De Tournes. In the official records the names of Heilman of Bienne, Switzerland, Weissenbruch and Robinet of Bouillon,[3] Rey of Amsterdam, Rousseau of Deux Ponts, and Lambert of Paris—to whom Panckoucke sold a one-third interest on June 8, 1770—often appear, usually with a statement by Cramer that he and De Tournes recognized none of them as partners, and that they were dealing with Panckoucke alone.

On June 26, 1770, before notary J. J. Dunant, Panckoucke, Gabriel Cramer, and Samuel De Tournes associated themselves for the purpose of publishing 2,200 folio sets of the *Encyclopédie*. A long agreement containing thirty-three articles was drawn up. In a preliminary statement Panckoucke declared that: (*a*) the first three volumes, except for thirty or forty sheets, were already printed and were being held in the Bastille; (*b*) two thousand copies of the first volume of plates had been retouched and printed and were in his shop in Paris; (*c*) the revisions to the second volume of plates had been practically completed; and (*d*) he had expended 69,296 livres for revisions, paper, printing, and other costs.

Among the most important of the provisions of the contract were: (1) Cramer and De Tournes were to be associated only for the purpose of the proposed Geneva folio edition and would have no permanent rights; (2) all concerned could sell their part in the enterprise only on the consent of all three partners; (3) Panckoucke was to be responsible for the printing, correction, binding, and storage of two thousand copies of the eight volumes of plates and the text concerning them; (4) Cramer and De Tournes were to print, correct, bind, and store two thousand copies of the fourteen volumes of text, for which Panckoucke was to furnish the type and paper, fifteen hundred reams of which were to be sent before September 1, so that the work could be begun during the following month; (5) inasmuch as the prospectus, already printed in Paris, and to be reprinted in Geneva, fixed the price of a complete set at 840 livres, the associates agreed to sell, during the course of the printing, no set for more than that sum, apportioned as follows: subscription forty-eight livres, seventeen volumes of text at twenty-four livres each, and eight of plates at forty-eight livres each; (6) the work was to be published in eight installments, the first of which, consisting of the first three volumes of text and the first of plates, was to come out during 1770, to be followed by deliveries every eight months of two volumes of text and one of plates. The first delivery was to be sent from Paris, subsequently the plates and text were to be sent simultaneously from Paris and Geneva, respectively; (7) on his return to Paris, Panckoucke was to send the detailed list of those who had sent subscriptions to him or his previous partners, so that Cramer and De Tournes might "judge the solidity of the subscribers"; (8) if by the action of a "sovereign will" the volumes held in the Bastille were never liberated, Cramer and De Tournes would sustain a third of the loss; (9) as a reward for services previously rendered,

[2] Voltaire, François-Marie Arouet de, *Œuvres complètes* **47**: 35, 48, 102, Paris, 1877-1885.

[3] For information on Weissenbruch, Pierre Rousseau, and J. B. Robinet, consult Charlier, Gustave and Roland Mortier, *Le Journal encyclopédique (1756-1793)*, Paris, 1952.

twenty-five complete sets would be given to M. Heilman of Bienne, and eight copies to Marc-Michel Rey of Amsterdam; (10) as soon as there were surplus funds available, Panckoucke would repay himself for the fifty louis d'or which he had sent to M. de Sartines to be distributed to the needy; (11) Samuel De Tournes personally and not the De Tournes Brothers was involved in the transaction. Inasmuch as the latter firm had an establishment in Lyons, Samuel De Tournes, "for the same reasons as M. Panckoucke," did not wish to have any interest in France in the enterprise. All prospectuses and all correspondence were to carry only the name "Cramer l'ainé et Compagnie."

In the unpublished Correspondance de Charles-Joseph Panckoucke in the Geneva Bibliothèque Publique et Universitaire[4] there is an important exchange of correspondence between Cramer and Panckoucke which reveals that there were differences and disagreements between the partners almost from the outset. On July 18, 1770, for example, less than a month after the signing of the contract, Cramer, after stating that he could purchase advantageously in Geneva the necessary paper for the missing sheets of the volumes in the Bastille, and asserting that De Tournes and he would hold strictly to all conditions of the agreement, complained that Panckoucke was proposing to have some of the printing done in Lyons and Bienne, and that he was now proposing that they publish twice as many volumes as had been specified in the contract of June 26 (p. 5).

Two months later, on September 9 (p. 9), Cramer and De Tournes were still awaiting the promised paper and type and were vexed that Panckoucke was more concerned with the Yverdon edition than in working on the plates. "On them," wrote Cramer, "rests the preference which is necessary to our edition." He also reminded Panckoucke that the three volumes, still in the Bastille, were "indispensable."

On March 1, 1771, the prospectus, signed "Cramer l'ainé et Compagnie," and dated "Genève, 20 février 1771," was being distributed in Geneva. This public announcement was the signal for the Venerable Company of Pastors of Geneva to take up arms against the project and to attempt to prevent its continuance through appeals to the Magnificent Council. The Pastors devoted many sessions to the problem and sent many delegations to outline their grievances to the Geneva civil authorities. The Magnificent Council, while seeming to sympathize with the disturbed Venerable Company, allowed the work to go on, perhaps because of their unwillingness to jeopardize the profits of the flourishing Geneva book trade. Because of the insights which these manoeuvres reveal, they will now be considered in considerable detail in the following paragraphs.

The Pastors' ardor against pernicious literature had already been kindled by the printing by Gabriel Cramer, the previous June, of a volume of Voltaire's *Questions sur l'Encyclopédie*, without having previously submitted the manuscript to the Geneva Scholarques.[5] And, again on September 7, 1770, the Pastors complained that in spite of the assurances which had been given them, two articles had appeared which "contain things contrary to the respect due to revelation" (p. 61). It is not surprising, therefore, that when, the following month, it became known that Cramer was preparing to print a new edition of the *Encyclopédie*, the Pastors' fears were aroused that the new edition might contain certain things "even more dangerous" than those of the first. The Ancient Magistrate was commissioned to request the First Syndic to prevent the printing of the work in Geneva (p. 67). The complaints of the Pastors in October and again in December were "well received" by the Syndics, who agreed to "take the matter under very serious consideration and to work with zeal to remedy the evil of which one complains." It is apparent from the Minutes of the Pastors of the following year that the civil authorities surreptitiously gave Cramer conditional permission in October and again on December 21 to proceed with the new edition, an action which was not revealed publicly until March 22 of the following year (p. 95).

It is not surprising, therefore, that when, on March 1, 1771, it was learned that copies of the prospectus, signed by Cramer et Compagnie, had been distributed, the Venerable Company voiced immediately its indignation that the book, in which "there are a great number of good, useful and agreeable things," but nonetheless "various elements which tend to undermine the foundations of the Christian religion and of all Revelation," should be allowed to be printed in Geneva. Furthermore, inasmuch as this same work contained among others an article "which has incensed all persons who have at heart the honor of Geneva and its religion," the Pastors could not understand

[4] Mss. supp. 148.

[5] Registres de la Vénérable Compagnie 30: 45.

how one could dare to reprint "word for word, line for line" a book in which such an article was to be found. The Moderator was commissioned to appeal to the First Syndic with the prayer that because of his known active interest "for religion and the honor of the State and the Church," he exercise his authority to stop the aforesaid reimpression.

The following day the Magnificent Council considered the Pastors' plea and voted to summon Cramer and censure him for having printed and distributed the prospectus (272: 150). In the ensuing hearing Cramer was reminded that he had promised not to make known the name of the printer and the place of publication of the reimpression. Cramer defended himself with the assertion that the offending prospectus had been printed only in order to be sent abroad, and that he would see to it that the article on Geneva "be modified to suit the wishes of the Venerable Company, and even, if it so desires, be wholly suppressed." In reference to the *Supplément* he agreed to print nothing that had not previously been approved by the Scholarques.[6] Whereupon the Magnificent Council voted to allow the *Encyclopédie* to be reprinted in Geneva under the following conditions: (1) that there be no mention of Geneva as the place of publication; (2) that the names of Cramer and De Tournes be not given; (3) that the article "Genève" be abridged, modified, and previously approved by the Scholarques; and (4) that the *Supplément* should not be printed until all articles had been seen and approved by the Scholarques.

A few days later the Venerable Company listened to the report of the Ancient Magistrate, who, with three associates, had brought their complaints before the civil authorities. The commission had learned that, when the tacit permission to proceed had been given Cramer in December the Syndic had "forgotten" to inform the Moderator, and that the Magnificent Council had taken no "fixed resolution." The delegates then made clear to the Council that there was a decided "contrast" between what Cramer had stated and what was printed in the prospectus, and expressed the Pastors' "grief . . . that the rules governing the book trade are not being observed" (p. 96).

On May 10, 1771, the Venerable Company approved a bill of complaints which was to be presented to the Council. Among its items were: (1) Why had the action of December 21, 1770, been announced only on March 22, 1771? (2) If the new edition was not to bear the name of Geneva, it was a proof that the Council was aware that the work was of such a nature that the public ought to be kept in the dark as to the place of publication; (3) Cramer should know that "the kind of permission which he had obtained was only conditional," and could be withdrawn at any time; (4) the Pastors regretted that their protest might prove prejudicial to the Geneva book industry, but insisted that this was a question of religion and public morals and that it was their duty "not to remain silent"; (5) although they were wounded by the imputations of the article "Genève," they were much more concerned about the *Encyclopédie's* attacks against religion; (6) they must insist that in the future all rules governing the press be rigidly enforced.

The matter seems to have been closed on June 7, 1771, when the reply to this paper of the Magnificent Council was read to the Venerable Company. The concluding statement was a promise of the First Syndic that "they would pay great attention to what the *Supplément* would contain, and that in general one would keep a close watch on all the booktrade" (p. 121).

Meanwhile Cramer's complaints continued. On March 26, 1771, he wrote Panckoucke, in reply to the latter's letters of March 7, 13 and 14, that he had plunged him into an "abominable abyss." The fourteen thousand copies of the prospectus which Panckoucke had sent De Tournes were "more than useless," and had been laid aside in the cloakroom. He was certain that the Geneva printing would not be delayed, but he feared that Panckoucke's plates were progressing slowly. Volumes seven and eight of plates were "infamous" and "absolutely inacceptable." "In God's name, take especial pains with the retouching of these volumes," he wrote. Panckoucke had requested that he say something more positive in reference to the *Supplément*. "What do you want, in God's name, that I say when I have already said all that I know?" he grumbled. He continued:

> I admit that I expected from you more of this warmth of sentiment. . . . All this ruinous establishment, have we not set it up only on your word given and repeated twenty times that we would be in charge of the *Supplément?* Would we have incurred all these expenses for the pleasure of killing our-

[6] The Scholarques had certain responsibilities for the care of educational buildings and finances, and were charged with the censorship of all printing.

selves with work on a thankless enterprise, bristling with thorns, which began with the privation of the three volumes of which we believed on your word the liberation early and easy, on an enterprise thwarted by the French government, and by the bawling of our Clergy, which is making itself heard by a part of the Council? . . . My extreme confidence in you has embarked me feeble-mindedly on an affair which troubles the best years of those which I still have to live. . . . All has turned out for the worst.

Despite their dissatisfactions with their partner, the Geneva printers were occupying themselves busily with their part of the task. On June 15, 1771, the *Journal Encyclopédique* reported that several volumes of the new edition would appear during the year and, on July 23, Voltaire deplored that the *Encyclopédie* was so monopolizing Cramer's time and affections that the Italian version of his *Henriade* was not being printed, as had been promised.[7]

The following year, on January 10, 1772, Cramer wrote Panckoucke again with criticism of his "horror for details" and with the recommendation that to avoid ruining himself, he should find a "well-born, intelligent, judicious, work and order loving" associate. He stated also that he could not understand why Panckoucke had recently proposed to buy out the shares held by De Tournes and himself (p. 15).

The state of the enterprise by early 1772 is made clear in a printed *Avis su sujet de l'Encyclopédie*, which Pierre Rousseau sent, together with a letter to Panckoucke, from Bouillon on April 3, 1772, which may be consulted in the Panckoucke Correspondance in the Geneva library. Herein it is stated that volumes six to eight of text and two of plates were then being delivered. The first volume of plates had appeared in 1771, and volumes one to three and nine of text would make up the third installment, and would be ready "toward the end of the year." Volumes three to four of plates would be delivered in May, 1773, and thereafter two volumes of text and one of plates would be ready every six months. One especial cause of the continuing complaints of Cramer and De Tournes was the matter of who was to print and share in the expected profits of the proposed *Supplément*. It will be recalled that in the contract of December 16, 1768, the original owners of the *Encyclopédie* reserved the right to publish four thousand copies of the *Supplément*, and that, in the transactions of July 1, 1769, and May 25, 1770, Panckoucke became the sole owner of the rights in the folio edition and in the *Supplément*.

In the deal of June 23, 1770, no mention was made of the *Supplément*, but it is obvious from the Correspondance that on September 12 of that year Cramer expected to have a share in this phase of the undertaking. He advised Panckoucke against including too many plates, which "retard, embarrass and raise the cost," and informed him that Heilman of Bienne was reporting that for having "believed too much" in Panckoucke, "no one believes any more in him." He stated further that M. de Haller and others "charged with working on the *Supplément*" were lamenting that they needed to know who was to be responsible for accepting their copy and "paying for it." De Tournes was unhappy about the "meagre" share which Panckoucke had assigned them. "He was counting on at least a third between us," wrote Cramer, who added that he would have been content with an eighth share for each, but that he was not pleased that Panckoucke seemed to doubt that "one would print the *Supplément* here." The following year the Geneva partners knew that Panckoucke had assigned a three-eighths share to Robinet of Bouillon, for, on March 26, 1771, Cramer asked him to take the three-eighths share of Bouillon, keep one for himself and send the other two to them in Geneva.

It was not until 1772, however, that serious preparations for the publishing of the *Supplément* were under way. Data on Panckoucke's negotiations with several proposed collaborators may be consulted in the Correspondance, where there are twelve letters from Robinet in Bouillon from March 1, 1772, to October 18 of the same year (pp. 70–90). In the first he informs Panckoucke that he will prepare the clause for the printing of "our" *Supplément*. "As for your associates in Paris," he wrote, "manage things as best you can. . . . They are little concerned whether the gentlemen from Geneva be connected with it or not, if everything is done equally well." On May 3, he wrote that Rousseau had informed him that Panckoucke wanted positively that the Genevans should have a part in the operation, and that he had granted them two-eighths and had withdrawn, "having assigned the other two eighths to M. Weissenbruch and to the children of M. Trecourt." He then asked whether Panckoucke was certain that Cramer would advance the funds to pay for the copy. On September 12, he advised

[7] Voltaire, François-Arouet de, *Œuvres complètes* **47**: 484, Paris, 1877–1885.

Panckoucke that the best solution was to divide the two-eighths into six twenty-fourths—two for Panckoucke, two for Rousseau, one for Rey, and one for him. "Have you made your final decision?" he asked, then added, "we will surely do the printing in Geneva. The Geneva gentlemen will be free to have one-eighth or two, as they will." The following week, on September 18, he wrote that he was surprised that Panckoucke had written "to Deux Ponts for the printing of the *Supplément*." Rousseau had not told him about that, he added, but, "on the contrary he appeared to me to be determined to have the printing done in Geneva." On October 18, he again wrote, announcing his withdrawal as associate and advising Panckoucke either to grant Rousseau all his share or to take all of his, so that "the affair may come out of the critical state in which it is."

As for Cramer, it is apparent that he hesitated to combine working on the *Supplément* with the main task of putting out the reimpression of the *Encyclopédie*. In August, 1772 (p. 25), he informed Panckoucke that it would be necessary that he be assured that the *Supplément* be "very well done," something of which Panckoucke could then "know nothing." On November 19 (p. 37), after telling Panckoucke that, if he were to raise funds to acquire the whole undertaking and to continue the work, he would go, neither to Bouillon, nor to Holland, nor to any other people whom he did not know, but to some "rich friends," so that, if there were to be no great profit, there would be no loss. As for the *Supplément*, he stated that he had withdrawn from the enterprise, seeing it "as a scheme to lure money" and that for "all the gold in the world he would not prostitute his name in proposing or boasting of a work which he could not know (p. 37).

After the intial slow start, differences between the partners, and temporary financial troubles, due to Panckoucke's "beautiful passion for new enterprises"—to use Cramer's words of August 21, 1772 (p. 26)—the printing seems to have progressed more rapidly, so that, by December, 1773, Voltaire could predict that "the new edition of the *Encyclopédie* is going to appear in Geneva." [8]

As the printing went on, Cramer and De Tournes became even more closely connected with the undertaking through a supplementary contract with Panckoucke of October 13, 1773, whereby they acquired a one-third interest in volumes nine through eleven of the plates.[9]

On June 13, 1775, however, their part ownership in the edition was terminated. On that date, in the offices of notaries Mercier and Dunant, a long paper of twenty-two articles was signed by the three partners. Among the most important stipulations were: (1) Panckoucke accepted the accounts of Cramer and De Tournes and their statement that up to May 1, 1775, 1,330 copies had been placed. He declared that his associates had fulfilled "all the engagements which they had made with him by the acts of June 26, 1770, and October 13, 1773. (2) By a contract of June 5, 1775, Cramer had sold to De Tournes all his rights to the entire undertaking. Panckoucke recognized De Tournes as the sole owner. (3) De Tournes sold to Panckoucke for one hundred and sixty thousand livres all his rights to the first twenty-five volumes, as well as the three volumes still sequestered in the Bastille. (4) De Tournes sold to Panckoucke for eighteen thousand livres his one-third interest in volumes nine through eleven of plates, acquired on October 13, 1773. (5) De Tournes, sole owner of a general index to the twenty-seven volumes of text, "which is being made by M. Mouchon," [10] sold to Panckoucke for twenty-two thousand livres his total interest, on condition that it be printed in Geneva. (6) Inasmuch as certain obstacles, "known by MM Cramer and De Tournes," did not allow Panckoucke to distribute the *Encyclopédie*, Cramer agreed to continue the sale of the work and the *Table* in Geneva, under the name of Cramer et Compagnie. (7) De Tournes agreed to direct "for the account and profit of M. Panckoucke" everything connected with the enterprise "in the same manner that he had conducted it when he had an interest in it," for "six years . . . the probable period . . . necessary to finish . . . the printing of the plates and the *Table*, and the disposal of the complete edition." (8) De Tournes would continue to provide for all the expenses and supplies "in order to bring the work to perfection." (9) De Tournes would continue to distribute volumes seven-eleven of the plates and the *Table* and would render accounts to Panckoucke every three months. (10) Delivery of volumes seven–eight of plates would be effected toward the end of 1775, volumes nine–

[8] *Idem.*

[9] Registres de Mercier et Dunant **12**: 484.

[10] For data on *Table, etc.*, see Watts, George B., The *Supplément* and the *Table analytique et raisonnée* of the *Encyclopédie*, *French Review* **28**: 18–19, 1954.

ten during 1776, volume eleven and the *Table* in 1777.

Once solely responsible for the undertaking, Panckoucke seems to have made rapid progress, for, a little more than a year later, in July, 1776, he announced in the *Journal des Sçavans* (August, 1776: 284) that he "had had the honor of furnishing" the twenty-eight volumes of a "reimpression made in Geneva," and, six months later, he stated in his own *Journal de politique et de littérature* that he had just finished "in Geneva a reimpression entirely in conformity with the edition of Paris."

No further references have been found to the first three volumes which were still in the Bastille in 1775, and it may be assumed that they were released shortly thereafter and were incorporated into the Geneva folio reimpression.[11]

[11] For data on the organization and regulations of the Geneva booktrade, see Kleinschmidt, John R., *Les imprimeurs et libraires de la république de Genève, 1700–1798*, Geneva, 1948.

GODS IN UNIFORM

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A PRELIMINARY remark will be needed on what is meant by the term "uniform" in the following pages.

A person carrying arms is not necessarily a uniformed person. Gods as well as goddesses are frequently armed. Athene is practically always helmeted and carries a lance. But she is dressed in a peplos or himation, and not in a uniform. Ares would, *ex officio*, be represented in arms, carrying a spear and a shield and wearing a helmet. But his costume is that of heroic or divine nudity, or of nudity loosely draped (fig. 1*a*), that is, a costume not practical for human warfare. It is, however, a different matter when the same god appears in a cuirass worn over a tunic (fig. 1*b*). For in this case he has donned an armor similar to, or even identical with, the standard army cuirass which the mercenaries in the Hellenistic monarchies received from the royal arsenals, or which the Roman legionaries purchased from the surplus depot of their outfit. The uniformlike attire might even be accentuated by the addition of certain badges or insignia of rank —an officer's sash, a torque, or a fibula.[1]

* * *

A sestertius, issued during the reign of Hadrian by the mint of Alexandria, shows the Dioscuri, the heavenly Twins Castor and Pollux, in military attire. They are clad in a Roman "body" or "muscled" cuirass to which there are attached, at the lower end, a row of metal lappets, the *pteryges*, with long leather tabs dangling down kilt-like and with similar leather flaps protecting the shoulders (fig. 2). The twin gods obviously sported the uniform of Roman legionaries or Roman officers.[2] This is an unusual feature. In classical times the Dioscuri were usually, though not always, naked except for their conical felt caps and their short cloaks or capes fluttering in the wind, as seen on the reverse side of so many coins of the Roman Republic.[3] They were always

FIG. 1*a–b*. Ares (mint of Alexandria).

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[1] For armed goddesses, see Le Lasseur, Denyse, *Les déesses armées dans l'art classique grec et leurs origines orientales*, Paris, 1919. The two coins of Ares, nude and cuirassed, are both from the mint of Alexandria and both issued under Antoninus Pius; see Dattari, G., *Numi Augg. Alexandrini—Monete imperiali greche*, pl. IX, nos. 2464 and 2460, Cairo, 1901. See below, nos. 51 f., for the rise of uniformed soldiery.

[2] Dattari, *Numi Augg. Alexandrini*, pl. XII, fig. 1681; Poole, Reginald Stuart, *Catalogue of the coins of Alexandria and the Nomes*, 84 and pl. V, fig. 708, London, 1892; Chapouthier, Fernand, *Les Dioscures au service d'une déesse*, 63 and pl. XI, fig. 54, Paris, 1935.

[3] It is true that heavily armed Dioscuri are found, though rarely, in some ancient vase paintings of the sixth century B.C.; see, e.g., Chapouthier, *op. cit.*, 199, fig. 23; but the meaning is held to be agonistic, and not military (*ibid.*, 202 ff.).

FIG. 2.

FIG. 3.

FIG. 4.

Dioscuri (mint of Alexandria).

conceived of as adolescents or ephebes, and they were the patrons of the Roman youth of equestrian nobility who prided themselves on going to battle with arms but without an armor.[4] There are, it is true, Alexandrian coins, of the same Hadrianic period, on which the Dioscuri appear according to the classical tradition: nude, facing each other, armed with their long lances, and holding their horses by the bridle (fig. 3). But the fact remains that a considerable number of issues of the Alexandrian mint depict the Twins in military dress (fig. 4), and it may be mentioned that with almost negligible exceptions all our evidence for the Dioscuri in uniform derives from Egypt and not earlier than the second century of our era.[5]

This is not simply a matter of chance. It is a well-known fact that the Egyptians, especially in Roman times, had a predilection for representing their own Graeco-Egyptian gods in military guise, a custom which almost certainly goes back to the Hellenistic-Ptolemaic era.[6] If we accept the view of Michael Rostovtzeff, the first Egyptian god who (as he puts it) "was enlisted in the regular army" was Heron, an equestrian god of foreign origin, but Egyptianized in Ptolemaic times. He appears indeed in Hellenistic rather than in Roman military dress: a cuirass made of plates or scales and decorated with the gorgoneion (fig. 5).[7] This Hellenistic armor is still worn by Heron in Roman times as seen in a painting from

FIG. 5. Theadelphia, temple of Pneferôs: Heron.

[4] Alföldi, Andreas, *Der frührömische Reiteradel und seine Ehrenabzeichen*, 46 ff., 49, Baden-Baden, 1952; Helbig, W., Die Castores als Schutzgötter der römischen Equitatus, *Hermes* **40**: 101 ff., 1905. A similar relationship may have existed between the Dioscuri and the Greek ephebes whose badge, the *petasos*, a broad-rimmed flat hat, was worn sometimes by the twin gods; *cf.* Chapouthier, *op. cit.*, 133, fig. 7.

[5] See Dattari, *op. cit.*, pl. XII, fig. 2485 (for the Dioscuri in the nude), and pl. XXIV, fig. 2863 (for another specimen of the uniformed gods). See also Chapouthier, *op. cit.*, 48 ff., fig. 26, for the wall painting from Theadelphia; *cf.* Breccia, Evaristo, *Teadelfia e il tempio di Pneferôs* (Monuments de l'Égypte gréco-romaine, I), 124 ff. and pl. LXI, fig. 1, Bergamo, 1926. Non-Egyptian is a relief from Telmessos (Pisidia), now in Vienna, where the Twin-gods are seen on horseback in the uniform of legionaries; see Chapouthier, 23 ff. and pl. I, fig. 2.

[6] Whereas Paribeni, R., Divinità straniere in abito militare romano, *Bulletin de la Société archéologique d'Alexandrie* **13**: 177 ff., 1910, and others rendered the *communis opinio* according to which no gods were pictured in military attire in pre-Roman times, Rostovtzeff, Michael, Kleinasiatische und syrische Götter im römischen Ägypten, *Aegyptus* **13**: 510 f., 1933, refutes this opinion by calling attention to the Hellenistic uniforms of gods in Palmyra and Dura.

[7] Rostovtzeff, *op. cit.*, 510 f. Breccia, *Teadelfia*, 110 ff., and pls. LVII, LVIII.

the Fayyûm, now in Paris (fig. 6), where the figure on the right represents that god.[8] A warning, however, should be sounded. The Hellenistic cuirass was still quite common in Roman times and is found with earlier Roman armor statues as well.[9] Therefore, a Hellenistic type of cuirass all by itself cannot be used without qualification as an evidence proving the pre-Roman date of a monument.

However that may be, Egyptian gods in uniform are numerous. Horus, the son of Isis and Osiris, is very often represented not simply armed, but in military garb. A bronze statuette of the second century A.D., now in the Louvre (fig. 7), shows the god with the sparrow hawk's head as a Roman officer, despite some non-Roman features.[10] His cuirass is scaled; he wears around his waist the officer's sash with fringed or tasseled ends, tied in a simple slip-knot, and not yet in the fashion characteristic of later statues of emperors and officers which displayed the so-called Hercules-knot with the ends tucked away.[11] Although his headgear, the white crown of Lower Egypt and the pendants of cloth, is Egyptian he is, nevertheless, decorated with the Graeco-Roman crown of laurel; and his head is surrounded by sun-rays suggesting the fusion of Horus and the sun god. Another hawk-headed Horus in

FIG. 6. Paris, panel from the Fayyûm: Heron (right).

FIG. 7. Louvre, bronze statuette: Horus.

[8] Cumont, F., Un dieu supposé syrien, associé à Hérôn en Égypte, *Mélanges syriens offerts à Monsieur René Dussaud* **1**: pl. I, facing p. 2, Paris, 1939.

[9] *Cf.* Vermeule III, Cornelius C., Hellenistic and Roman cuirassed statues, *Berytus* **13**: 5 and 40, 1959, who (p. 18) styles the statue of M. Holconius Rufus of the Augustan period (pl. IV, fig. 13) the first complete statue that may be called Roman without being based on Hellenistic tradition. In the classicistic atmosphere of the second century after Christ, the Hellenistic armor was occasionally revived; see, e.g., Vermeule, *op. cit.*, 5, 57, 60, 61 (nos. 225–249).

[10] Chapot, Victor, L'Horus garde-frontière du Nome Sethroïthe, *Mélanges Maspéro* (Mémoires . . . de l'institute française d'archéologie orientale du Caire **67** (2): 225 ff., pls. I–II, 1935–1937.

[11] For the sash tied in a Hercules-knot, see Delbrück, Richard, *Die Consulardiptychen*, 41, Berlin und Leipzig, 1929; Keyssner, Karl, art. "Nodus," *RE* **17** (1): 807 f., 1936, on the *nodus Herculaneus*.

FIG. 8. Cairo, Coll. Fouquet, terracotta: Horus.

military attire is in the British Museum. The type is quite frequent.[12] The same type, for example, has been worked into a terracotta bust where the decorated cuirass may suggest officer's rank (fig. 8).[13] How common it was to represent also the youthful Horus, in his hypostasis as Harpocrates, in military dress may be gathered from a figurine in the collection of Arthur D. Nock. The terracotta of Horus putting his hand to his mouth is doubtless mass fabrication; but even so it displays essentially, if in shorthand, the customary features: the armor with the leather tabs, the sash, and a baldric running from the left shoulder to the right hip (fig. 9).[14]

One more statuette of Horus, in the Collection Sinadino in Alexandria, (fig. 10), should be mentioned here on account of the posture; the right arm, so often broken away, is raised and one finger lifted. This hand, perhaps, held originally a spear, unless it was meant to be a gesture of imperatorial greeting. At any rate, the military dress is very accurately that of a Roman officer: the muscled cuirass, the *pteryges* with the leather tabs, and the sash around the waist.[15] Other Egyptian gods display a similar attitude. Of those therianthropic deities the god Apis, with his head of a steer, is among the best known. He appears likewise in full uniform; his right hand is open and raised in a gesture known from Roman emperors when addressing their legions, and the editor of this little bronze statuette, Baron von Bissing, gave it the title of *Apis Imperator* in the attitude of the *allocutio* (fig. 11).[16] We can-

FIG. 9. Cambridge, Coll. A. D. Nock, terracotta: Harpocrates.

[12] See Chapot, *op. cit.*, pl. II, left figure, for a Horus in the British Museum. Clermont-Ganneau, Ch., Horus et Saint Georges, *Revue archéologique* **33**: 24, 1877, mentions two other statuettes of Horus in military dress in the British Museum; *cf.* Chapot, *op. cit.*, 228.

[13] Perdrizet, P., *Les terres cuites grecques d'Égypte de la Collection Fouquet* **2**: pl. LI, Nancy, Paris, and Strasbourg, 1921.

[14] I am very much obliged to Professor Arthur D. Nock for calling my attention to, and providing me with a photo of, his interesting terracotta.

[15] Von Bissing, Die Nekropole von Kôm-esch-Schukâfa, *Expedition Ernst Sieglin* **1**: 149, fig. 93, Leipzig, 1908.

[16] Von Bissing, Eine Apisfigur in der Haltung der *Adlocutio*, *Oriental Studies dedicated to Paul Haupt*, ed. Cyrus Adler and Aaron Ember, 295–299, Baltimore and Leipzig, 1926. The same, or a similar figure, is discussed by Breccia, E., Osiris-Apis in abito militare romano, *Bulletin de la société archéologique d'Alexandrie*

FIG. 10. Alexandria, former Coll. Sinadino, bronze: Horus.

not tell whether the dog-headed Anubis of the National Museum in Athens had the same attitude, since the right hand is broken away from this bronze statuette; but he, too, appears in uniform with two rows of lappets covering the tunic of which the lower edge becomes visible.[17] Another Anubis, in the Museo Nazionale in Rome, wearing a decorated armor, suggests that the god held in his right hand a spear or a staff scepter (fig. 12).[18] Yet another god, perhaps Onpwaut-Makedon, also therianthropic, is represented in uniform and shown with his right arm raised.[19]

The general appearance of all those Egyptian gods is closely related to a small bronze statuette from the Delta, now in the Louvre (fig. 13).[20] It displays a person in military attire: cuirass with *pteryges*, and leather tabs, the sash with its characteristic knotting, and shoulder tabs. The rays of the sun god surround the head. The person represented is Alexander or rather Alexander-Helios, that is, Alexander as a god. It is true, the statuette is of Roman times but it may be a replica of an earlier work of art of that type. The attitude should perhaps be compared with that of a Ptolemaic bronze statuette showing Alexander in the aegis of Zeus, normally an attribute of Zeus' daughter Athene, but here given to Alexander the god who was venerated in Alexandria (fig. 14).[21] It has been assumed that

FIG. 11. Former Coll. Bissing, bronze statuette: Apis.

17: 184, 1919–1920. The interesting article by Alfred Hermann, Der letzte Apisstier, *Jahrbuch für Antike und Christentum* **3**: 34–50, 1960, reached me only after I had returned the proofs; see, however, esp. 40 f. for the Apis in military attire, and n. 53, for a correction of von Bissing.

[17] Von Bissing, *Ägyptische Kultbilder der Ptolomaier- und Römerzeit* (Der alte Orient **34**, 1–2), 17 ff., fig. 16*a*, Leipzig, 1936.

[18] *Cf.* Paribeni (above, n. 6), pl. VI–VII. My thanks go to the German Archaeological Institute, in Rome, for providing me with a photo of this statuette (Photo No. 60.1199).

[19] Von Bissing, in *Expedition Ernst Sieglin* **1**: 143, fig. 89, from the Collection Sinadino, in Alexandria.

[20] Schreiber, Theodor, *Studien über das Bildnis Alexanders des Grossen* (Abhandlungen d. Sächsischen Gesellsch. d. Wissensch. **21**, 3), 72 f., 140, and pl. VII, fig. P., Leipzig, 1903. Von Bissing, Eine Apisfigur (above n. 16), 296, has connected the Apis-*Adlocutio* statuette with the Alexander in the Louvre, but did not follow up his observation. I owe the Giraudon photo to the kindness of Professor Sirarpie Der Nersessian, in Dumbarton Oaks. For Alexander as a Moon-god, with a crescent and three stars, see Cumont, *Recherches sur le symbolisme funéraire des Romains*, pl. XVI, fig. 1, and p. 208, Paris, 1942.

[21] Perdrizet, Paul, Un type inédit de la plastique grecque: Alexandre à l'égide, *Monuments Piot* **21**: 59–72, pls. IV–V, 1913. See pp. 70 f. for the hypothesis linking this statuette to Lysippus' sculpture of Alexander.

the attitude of Alexander in the aegis may go back to a statue by Lysippus which, if this be true, would have influenced also the statuettes of so many of the therianthropic gods previously discussed. Probably the Horus in the Louvre (fig. 7) had also the right hand raised and thus would resemble, with his crown of sun rays, the Alexander statuette (fig. 13) in more than one detail. It would, indeed, be very tempting to draw the straight-forward conclusion that Alexander was the first "god in uniform" and that he, general and god at the same time—as depicted also

FIG. 12. Rome, Museo Nazionale, bronze statuette: Anubis.

FIG. 13. Louvre, bronze statuette: Alexander (Photo Giraudon).

in a decadrachme of the mint of Babylon [22]—started the Egyptian-Alexandrian tradition of representing not only the native gods in military attire but also the Graeco-Roman gods who in classical times were preferably represented in the nude or loosely draped. But it does not seem likely that this simple and plausible hypothesis can be proved. Nevertheless, the similarity of gesture and attitude displayed by the statuettes of Horus, Apis, and Anubis, and by that of Alexander may suggest that they all followed some common model which may have been as famous as Lysippus' statue of Alexander; more likely,

[22] Professor Alfred R. Bellinger obligingly called my attention to this decadrachm which shows Alexander wearing the cuirass and holding in his right, extended, hand the thunderbolt; his head-dress is Persian. *Cf.* Hill, George Francis, *Catalogue of the Greek coins of Arabia, Mesopotamia, and Persia*, 191, No. 61, and pl. XXII, fig. 18, London, 1922.

Fig. 14. Cairo, Coll. Fouquet, bronze: Alexander with Aegis.

however, we have to take into account some radiations of the canonical Doryphoros pose.

It should be added, if only in parenthesis, that in Egypt also other deities were represented in military garb, and that representations following that pattern are found even in so small works of art as amulets. One amulet shows without doubt Anubis in the dress of a soldier (fig. 15),[23] the same god who in a necropole at Alexandria is shown as anguipede, cuirassed and decorated with the *paludamentum* (fig. 16).[24] Such snake-legged deities are not rare on amulets either, where we find, for example, a lion-headed god in military dress (fig. 17).[25] In Egypt, however, also a Greek goddess, such as Nemesis or the Roman *dea Roma* (fig. 18), was occasionally represented as a military person,[26] apparently for no other reason than to accommodate to a taste which certainly had gained its full strength in Roman times.

This does not imply that the custom of picturing the gods in officers' uniform developed under the Roman domination only. On the

Fig. 15. Magical amulet: Anubis (Metropolitan Museum, New York). (Enlarged.)

[23] Bonner, Campbell, *Studies in magical amulets, chiefly Graeco-Egyptian*, pl. II, fig. 38, and p. 259, Ann Arbor, 1950. Another amulet shows not Anubis but Seth, likewise in armor; *cf.* Griffiths, J. Gwyn, Seth or Anubis? *Jour. Warburg and Courtauld Institutes* **22**: 367 ff., and pl. 38, *a*, 1959.

[24] Von Bissing, *Ägyptische Kultbilder*, fig. 14*a*; *Expedition Ernst Sieglin* **1**: 142. The present reproduction was made after a line drawing from the portfolio *Les bas-reliefs de Kom-el-Chougafa*, ed. F. W. von Bissing and Gilleron, pl. XIII, Munich, 1901, by courtesy of the Dumbarton Oaks Library.

[25] Bonner, Campbell, *Magical amulets*, pl. V, 99–101; pl. VIII, 172. *Cf.* Nilsson, Martin P., The anguipede of the magical amulets, *Harvard Theological Review* **44**: 61 ff., 1951.

[26] Perdrizet, P., Némésis, *Bulletin de Correspondance Hellénique* **36**: 263 ff., fig. 1, 1912. For the *Dea Roma* on Alexandrian coins, see Dattari, *Numi Augg. Alex.*, pl. XXI, No. 4994; also Poole, *Coins of Alexandria*, pl. XXIII, fig. 240. Seyrig, in *Syria* **13**: 263, 1932, considers "the case [of the Alexandrian Roma] exceptional." See, in general, Vermeule, *The goddess Roma in ancient art*, Cambridge, Mass., 1959, who, however, does not discuss the Alexandrian coin nor the Roma type represented by it.

FIG. 16. Alexandria, Kom-el Chougafa: Anubis anguipede.

FIG. 17. Magical amulet: lion-headed god (Univ. of Michigan). (Enlarged.)

FIG. 18. Dea Roma (mint of Alexandria).

contrary, the findings in Palmyra, Dura-Europos, and Hatra make it perfectly clear that the tradition of providing gods with military trappings was pre-Roman and went back to Hellenistic times. A Palmyrene relief in the Louvre of the first half of the first century after Christ (fig. 19) shows a triad of gods.[27] We recognize in the center a bearded deity, identified as Bēl, wearing a *kalathos* on his head and a diadem with fringed ends. The armor is made of small rectangular scales; the shoulder straps are fastened with rings. Where we normally would find the *pteryges* we see rows of pearls and a meander

FIG. 19. Louvre, relief from Palmyra: triad of gods.

[27] Seyrig, *Antiquités Syriennes* **4**: 31, pl. II, 1953; Morehart, Mary, Early sculpture in Palmyra, *Berytus* **12**: 60 f. and fig. 11, also figs. 12, 13, 1956–1957. The number of Palmyrene gods in military dress is excessively great and no effort has been made here to assemble the material completely. For the triad of Bēl, Jarhibol, and Aglibol, see also Eissfeldt, Otto, *Tempel und Kulte syrischer Städte in hellenistisch-römischer Zeit* (Der alte Orient **40**), 83 ff., 1941.

FIG. 20. Palmyra, relief: Helios Theos Megistos.

pattern decorating the lower edge of the cuirass —an Oriental tendency to a certain enrichment of the costume.[28] Dangling down from the armor are two rows of fringed leather flaps. The tight trousers are visible under the edge of a tunic which has long sleeves, a *tunica manicata*. The officer's belt is likewise fringed. The god wears a *paludamentum* which is held by a plaque or fibula on, or just below, the right shoulder. The same uniform (though without the Parthian trousers but enriched by a torque, a necklace

FIG. 21. Palmyra, pottery tessera: Aglibol.

[28] See, for that tendency, Vermeule, *Cuirassed statues*, 25 f.

FIG. 22. Rome, Capitol, aedicula: Aglibol with Malakbēl.

usually of twisted gold) is worn by the gods to the right and left: the one to the right is Jarhibol, the sun-god of Palmyra; to the left is Aglibol, the moon god, identifiable by the crescent in his halo of sun rays.

The emblem of the crescent, however, does not always identify the deity with certainty as the moon god. There is, for example, the bust of a cuirassed god whom the description, despite the crescent, calls plainly *Helios Theos megistos* (fig. 20); the date is known accurately in this case: A.D. 30.[29] This representation must have been rather popular; for the same design is seen on a *tessera* from Palmyra (fig. 21) where the image of the cuirassed bust of the god decorates the small terracotta token serving its bearer to secure a meal on the feasts of the god.[30] At a later

[29] Seyrig, Antiquités syriennes, § 72: Bas-relief palmyrénien dédié au soleil, *Syria* **36**: 58 ff. and pl. XI, 5, 1959.

[30] Seyrig, *Antiquités syriennes* **2**: 116, fig. 50, Paris, 1938. For the purpose of the *tesserae*, see Seyrig, *ibid.*,

period, the Hellenistic cuirass was replaced by a Roman armor. An *aedicula* in the Capitoline Museum in Rome, dated A.D. 235, shows Aglibol with the crescent in a simple Roman body cuirass, extending his hand to Malakbēl (fig. 22).[31] It is surprising to find how consistently Palmyrene gods were represented in uniform. Shadrafa, for example, a god whose name is said to be derived from Satrap, the title of the ancient Persian provincial governors, wears a Hellenistic plate armor with sash as well as the long-sleeved tunic and the Parthian trousers (fig. 23).[32] The blending of Hellenistic and Parthian elements characterizes not only the military attire of the Palmyrene gods, but also frequently that of the gods of Dura-Europos.[33] A bas-relief of a local god of Dura, Aphlad, son of Hadad, which belongs to the middle of the first century, shows the god in Parthian trousers and in a long-sleeved tunic over which he wears an armor decorated with stars. We notice the sash, and also the torque around his neck (fig. 24).[34] Again, at a later

FIG. 23. Palmyra, relief: Shadrafa.

FIG. 24. Palmyra, relief: Aphlad.

and in *Syria* **16**: 394 f., 1935; also his study Les tessères palmyréniennes et le banquet rituel, *Mémorial [M.-J.] Lagrange*, 51–58, Paris, 1940. *Cf.* F. Cumont, *Recherches sur le symbolisme funéraire des Romains*, 208, Paris, 1942.

[31] Seyrig, *Antiquités syriennes* **2**: 100, pl. XXXI; also in *Syria* **18**: 203, pl. XXXI, 1937. I owe the photo to the courtesy of the German Archaeological Institute, in Rome (No. 1936.1108). For Malakbēl in his relation to Aglibol, see Eissfeldt, *Tempel und Kultc*, 89 f.

[32] Seyrig, Note sur les plus anciennes sculptures palmyréniennes, *Berytus* **3**: 137, pl. XXX, 1936; *cf. Annales archéologiques de Syrie* **7**: pl. VIII, fig. 2, 1957; Morehart, Mary, in *Berytus* **12**: 63, and figs. 14 and 15, 1956–1957. For Shadrafa, see Seyrig, *Antiquités syriennes* **2**: 23, n. 4, 1938; Eissfeldt, *Tempel und Kultc*, 102 f.

[33] Hopkins, Clark, Aspects of Parthian art in the light of discoveries from Dura-Europos, *Berytus* **3**: pl. III, fig. 1, facing p. 6, 1936, ([Aphlad] "clothed in the dress of a Hellenistic officer"). *Cf.* Hopkins, C., in: *The excavations at Dura-Europos: preliminary report* **5**: 107 ff. and pl. XIII, 1934. Rostovtzeff, Dura and the problem of Parthian art, *Yale Classical Studies* **5**: figs. 36 and 38, 1935; see *ibid.*, 160 ff., and *Dura-Europos and its art*, Oxford, 1938, for the blending of Parthian and Hellenistic elements; Seyrig, *Antiquités syriennes* **2**: 45–73, 1938.

[34] Hopkins, Clark, in *Berytus* **3**: pl. III, fig. 1, facing p. 6. *Cf.* Rostovtzeff, *Dura-Europos and its art*, p. 87;

FIG. 25. Dura-Europos, wallpainting: sacrifice to Jarhibol.

period, the gods of Dura would be dressed in a garb of more Roman appearance, as, for example, the statue of Jarhibol, the sun god, in a wall-painting of the Artemis temple, annexed to the Praetorium (fig. 25);[35] or the statues of three haloed gods in a fresco dedicated by the Tribune Terentius (fig. 26).[36] The gods wear the golden

FIG. 26. Dura-Europos, wallpainting: three gods.

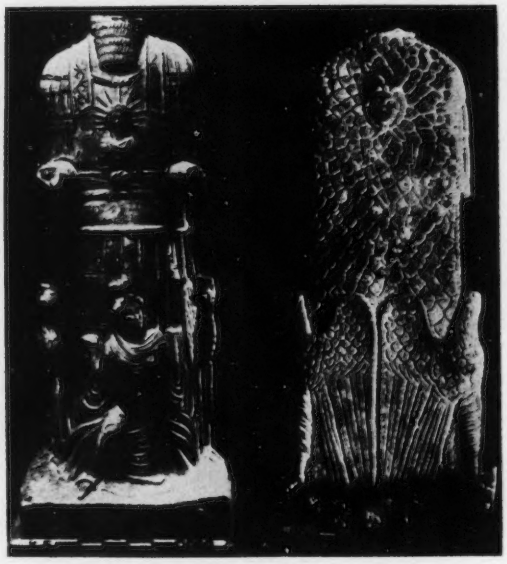

FIG. 27. Hatra, marble statue: Assur-Bēl.

cuirasses of a full-dress uniform; their silver sashes, however, are more richly decorated than those of Roman officers, nor are they knotted in the same way.

Rather impressive is the recently excavated marble statue of Assur-Bēl of Hatra (south of Mosul), of the first century after Christ (fig. 27).[37] The cuirass differs from most Hellenistic and Roman patterns. The *pteryges* are absent; hence, the two rows of leather tabs dangle down from the cuirass directly; and instead of one row of leather flaps there are three. Moreover, the cuirass is decorated with a bust of Helios whose relief is found occasionally also on imperial armor.[38] The sash is broader than usual, but knotted in the customary way. This god wears also a torque around his neck. Crouched to his feet, between two eagles, is the Tyche of

"wears a Hellenistic military dress with some Iranian features," and p. 65 for the god himself. For Aphlad, son of Hadad, see Eissfeldt, *Tempel und Kultc*, 139 f.

[35] Rostovtzeff, in *Yale Classical Studies* **5**: fig. 57, and p. 249, 1935; Hopkins, in *Dura Report* **5**: 153 ff., and pl. XXXVI, figs. 1-2.

[36] Seyrig, *Antiquités syriennes* **1**: pl. XLIII, 1934; see, for a colored plate, Cumont, F., *Fouilles de Doura-Europos*, pls. I. and LI, fig. 1, Paris, 1926. For the golden armor worn by Roman emperors, see Delbrück, *Die Consulardiptychen*, 41; also Vermeule, *Cuirassed statues*, 43, No. 76.

[37] *Illustrated London News*, 116, figs. 5–6, Dec. 18, 1954. Lenzen, Heinrich, Ausgrabungen in Hatra, *Archäologischer Anzeiger* **70**: 339–342, figs. 2 and 3, 1955. I am much obliged to Sir Ronald Syme for having called my attention to the monuments of Hatra.

[38] The cuirass resembles one in the Olympia Museum; *cf.* Vermeule, *Cuirassed statues*, pl. XIX, fig. 58, and p. 61, No. 232. For Helios on imperial breastplates, see, e.g., Brendel, Otto, Der Schild des Achilles, *Die Antike* **12**: 272 ff., esp. 276 f. (figs. 3–4), and 278 (fig. 5), 1936; Mancini, Gioacchino, Le statue loricate imperiali, *Bullettino della Commissione archeologica communale di Roma* **50**: 181 (Nos. 17, 18) and 183 (No. 29), 1923, for *Sol* on imperial armor.

FIG. 28. Hatra, relief: sun god.

Hatra. The back of the monument does not repeat the military armor, but displays instead the aegis with the head of Gorgo; it reminds us of the aegis statue of Alexander the Great (fig. 14). Also at Hatra there is a bust of the sun god in military attire (fig. 28), similar to the busts of Aglibol at Palmyra, but lacking the crescent. The inscription styles the god "The Lord of Offering," and the editor suggests, though without evidence, that the armored god may be Mithras.[39] The shoulder clasps of his cuirass are decorated with eagles, and on a military standard flanked by the eagles of Hatra, the bust of the god is seen once more as a plaque.[40] Here then the image of the cuirassed sun-god has become an object of applied art just as the images of Roman emperors were attached to insignia or displayed on *phalerae* and other military paraphernalia.[41]

There were, of course, many more gods in Syria and Asia Minor who were represented in uniform. Strangely enough the soldier god *par excellence*, Mithras, appears, it seems, only once in military dress, on a coin of Tarsus (fig. 29), and nowhere else.[42] But another god who was venerated in the military camps, *Juppiter Dolichenus*, is practically always represented in the officer's garb.[43] Swinging in his right hand the double-axe, he is often seen in a simple Roman muscled armor (fig. 30),[44] though he too may wear the

FIG. 29. Tarsus, coin: Mithras (enlarged).

FIG. 30. Berlin, Antiquarium: Dolichenus.

[39] *Illustrated London News*, 806 f., fig. 8, Nov. 17, 1951. For Mithras, see below, n. 42.

[40] *Illustrated London News*, fig. 9, *loc. cit.*

[41] For *phalerae*, see Alföldi, *Der frührömische Reiteradel und seine Ehrenabzeichen*, 17 ff., Baden-Baden, 1952; and his Zu den römischen Reiterscheiben, *Germania* **30**: 187–190, 1952. Probably the Caracalla plaque, reproduced by Brendel, in *Die Antike* **12**: 275, fig. 2, served also as an insignia.

[42] Hill, G. F., *Catalogue of Greek coins of Lycaonia, Isauria, and Cilicia*, 213, No. 258, and pl. XXXVII, fig. 4, London, 1900. *Cf.* Will, E., *Le relief cultuel*, 259, n. 2, who emphasizes the absence of Mithras representations in military attire. For a full bibliography, see Vermaseren, Maarten J., *Corpus inscriptionum et monumentorum religionis Mithriacae*, 52, fig. 27, and pl. I, fig. 4, Haag, 1956.

[43] Kahn, A. H., *Juppiter Dolichenus*, Leiden, 1943. The latest study, by Merlat, P., *Jupiter Dolichenus: Essai d'interprétation et de Synthèse*, Paris, 1960, has not yet been accessible to me.

[44] See, e.g., the relief found in Rome (Antiquarium in Berlin) and discussed by Seyrig, *Syria* **14**: pl. XXXVIII, fig. 2, 1933; *cf.* Kahn, *op. cit.*, 117 f. and pl. XIII, fig. 21.

FIG. 31. Hauran, Syria, altar fragment: Asklepios.

trousers of the oriental gods.[45] But as in Egypt so in Syria some definitely Greek gods were represented in armor. Asklepios repeatedly appears in uniform in Syrian monuments, for example on an altar in Hauran where he is seen in a Roman muscled cuirass (fig. 31).[46]

It will be unnecessary for our purpose to give a fuller catalogue of representations of gods in military dress, since the material cited here will suffice to pose a few questions regarding some principles involved.

The appearance of so many, and especially oriental, gods in uniform is difficult to explain. The hypothesis according to which these gods should be considered "soldier gods," who in this capacity donned military attire, has been abandoned long ago.[47] And another suggestion advancing the theory that those gods were considered commanders-in-chief of their religious followers who thus formed a kind of *militia dei* or *deorum*, is not sound either, because it carries later Christian metaphors as realities into the pagan past.[48] The problem should perhaps be attacked in a less straightforward and more circumstantial way.

Treacherous though it is to start from a modern parallel, we should, nevertheless, recall the fact that the custom of European monarchs to appear almost perpetually in some regimental uniform, or in that of a general of the army, was a very late one. It began in the eighteenth century, and became the general habit apparently only by the time of the Napoleonic wars and thereafter. That is to say, it began at a time when the continental nations asserted themselves as military monarchies, with a prevalence of the military at large.

Something similar must have happened in the military monarchies of the Hellenistic world.

1) There were, in classical times, citizens bearing arms and providing their own armor, but there was not a uniformed soldiery.[49] Alexander's *Argyraspides*, however, his *corps d'élite* of "silver-shielded" guards, were a uniformed unit which survived the death of their king. The *Argyraspides* were continued by some of the Diadochs, notably by the Seleucid rulers of Syria.[50] Moreover, in the Hellenistic monarchies the mercenaries received their arms and armor from the royal arsenals instead of themselves providing for their armature as private citizens.[51] The same became true in Rome. Ever since the times of Marius the legions carried standardized arms and armor, even though the individual legionary had to pay for his equipment; its value was gradually deducted from his pay in monthly instalments.[52] At any rate, from the Hellenistic period onward we may talk about "uniformed" soldiers.

2) We have to consider the cuirassed statues of kings and generals and recall their history. In

[45] The Renaissance drawing by Pirro Ligorio (sixteenth century) of the Berlin relief shows that the god wore the Oriental trousers; Seyrig, *op. cit.*, 370, fig. 1; Kahn, *op. cit.*, 117 ff.

[46] Jalabert, Louis, *Inscriptions grecques et latines de Syrie*, 157 ff. and pl. II, Beirut, 1906; Baudissin, Graf W. W., *Adonis und Esmun*, 299 and pl. IX, fig. 1, Leipzig, 1911.

[47] This was, more or less, the current opinion recently refuted by Will, E., *Le relief cultuel*, 259 f.

[48] Von Bissing, *Ägyptische Kultbilder*, 22 f., 1936; against his hypothesis, see Will, *op. cit.*, 206 f.

[49] The military costume had no roots in the national traditions of the East. "Ceci pour la bonne raison qu'il n'existait pas d'uniforme à haute époque; le guerrier se distinguait du civil non par son accoutrement . . . mais par les armes qu'il tenait à la main." *Cf.* Will, *op. cit.*, 264.

[50] *Cf.* Droysen, H., Argyraspides, *RE* **2**, 1: 800 f., 1895; also his *Heerwesen und Kriegsführung der Griechen*, 155, Freiburg, 1889; and, for the red cloaks of the Spartans, *ibid.*, 24 and 155, n. 2; Plutarch, *Philopoimen*, ii.

[51] Von Domaszewski, Alfred, Bewaffnung, *RE* **3**: 376, lines 60 f., 1897.

[52] Domaszewski, *op. cit.*, 377, lines 52 ff. MacMullen, Ramsay, Inscriptions on armor and the supply of arms in the Roman empire, *Amer. Jour. Archaeology* **64**: 23 ff., 1960.

his very thorough study of this subject, Professor Cornelius C. Vermeule has pointed out that cuirassed statues began to make their appearance sporadically in Hellenistic times, whereas in classical times generals and princes would have been represented preferably in divine or heroic guise, that is, more or less naked or draped.[53] The earlier Roman cuirassed statues still displayed the influence of Hellenistic armor; thereafter Rome used the "muscled" or "body" cuirass which often was richly decorated, especially the ceremonial armors of emperors, princes, and generals. The statue of Augustus from Prima Porta demonstrates that decorated cuirass, while the barefootedness of the emperor still seems to suggest the nudity of the gods. The high tide of imperial cuirassed statues, however, falls in the second century after Christ when, according to Professor Vermeule, "one senses that the emperors systematically populated the cities of North Africa and Asia Minor with their cuirassed statues."[54] And in another connection he stresses the fact that "the Trajanic and Hadrianic periods produced the greatest number of [cuirassed] statues."[55]

3) Together with the history of cuirassed statues, that of the Roman trophies should be considered, that is, of the cuirassed mannequins with armor placed on a pole. In his illuminating study on the Roman trophy, Professor Gilbert Charles Picard has pointed out that this ritual monument of victory does not antedate, in Greek art and literature, the late sixth or even early fifth century, and that, when it achieved greater popularity in Hellenistic times as an expression of Greek triumphal art, the trophies celebrated mainly the *Tyche* or *Eutychia* of the victorious general, his luck or good fortune.[56] In the Hellenistic monarchies, however, it referred also to the *Arete* of the king. In this sense, the trophy was inherited by Rome where its meaning still was that of the *Felicitas* of the victor, though it was linked under Augustus also to the Genius of the general, to the *genius Augusti*.[57] By the second century of our era, the theology of *Eutychia*, or Latin *Felicitas*, was gradually eclipsed by that of the *Virtus* of the general, that is, of the emperor whose *Virtus perpetua* was the ultimate cause of victory. Hence, the cuirass trophies became monuments for, or symbols of, the victories of the emperor exclusively and of his *Virtus invicta*—one of the axioms of the late-imperial theology of victory.[58] Perhaps it may be said that the cuirassed statues of emperors, which became so overabundant in the Trajanic and Hadrianic period, made the armored ruler himself, as it were, a τρόπαιον ἔμψυχον, a living trophy glorifying the emperor's *Virtus perpetua*, his perpetual prowess and moral excellence.

4) There is reason to consult the evidence of the coins as well. Professor A. Alföldi has demonstrated strikingly that the Roman emperors in the time of the Principate were not supposed, or even not allowed, to wear the uniform and insignia of an *imperator* within the *pomerium* of Rome—except on the occasion of a *profectio* or some other strictly military event.[59] Normally they wore the toga, that is, civilian clothes. Hence, it was only another indication of the final prevalence of the military over the civilian (the latter represented by the Senate) that eventually, as has been aptly remarked, the *façade civile* gave way to the *réalité militaire*.[60] By the end of the first century the emperor wore almost always, even within the *pomerium* of Rome, military attire with the attributes and insignia of his rank, excepting only the occasions when he performed religious functions or met the Senate.

The coins illustrate this development with all the clarity that we could desire. The obverse side of Roman coins displays as a rule the portrait head of the emperor. Of the Julian-Claudian house there is, with the exception of one sestertius of Nero, not a single coin which shows the emperor other than naked, that is, bare-necked.[61]

[53] Vermeule, *Cuirassed statues* (see above, n. 9), 7. Heckler, Anton, Beiträge zur Geschichte der antiken Panzerstatuen, *Jahreshefte des österreichischen archäologischen Instituts* **19–20**: 192 f., 1919, emphasizes very strongly that, with the exception of a coin for Themistocles, generals were not represented in armor during the classical period.

[54] Vermeule, *op. cit.*, 7. See also Hanfmann, George M. A., A new Trajan, *Amer. Jour. of Archaeology* **61**: 228, and 226, n. 18, 1957, for the barefootedness of Augustus.

[55] Vermeule, *op. cit.*, 5.

[56] Picard, Gilbert Charles, *Les trophées romains: Contribution à l'histoire de la religion et de l'art triomphal de Rome*, 36 ff., Paris, 1957.

[57] Picard, *op. cit.*, 168, 268 ff.

[58] Picard, *op. cit.*, 371 ff.; see 466 ff., for the imperial theology of victory.

[59] Alföldi, Insignien und Tracht der römischen Kaiser, *Deutsches archäologisches Institut: Römische Mitteilungen* **50**: 9 ff., 43 ff., 47 f., 1935.

[60] Alföldi, *op. cit.*, 43.

[61] *Cf.* Mattingly **1**: p. clxxi, and pl. XLI, fig. 1 (p. 215, No. 111). For Galba, see **1**: p. lxiv, and pl. LII, fig. 6 (p. 310, No. 13). This refers only to the portrait on the obverse side of the coins; for on the reverse the

Cuirassed portraits on coins remain extremely rare until the end of the first century. Then, under the emperors by adoption, the cuirassed image is found more frequently; it begins to prevail in the second half of the second century. In the third, the naked bust becomes almost obsolete and a real rarity, though it is still occasionally found under Septimius Severus, Caracalla, and Geta, and later under Gordian III, Gallienus, and Probus. The naked bust, however, is regularly found on coins commemorating the consecrated rulers; it becomes a privilege of the *Divi*.[62] The last pieces showing the emperor naked, that is, bare-necked, are a few beautiful medallions of Constantine the Great, one of which shows in the reverse, significantly, the emperor in uniform carrying a trophy over his left shoulder, with the inscription: VIRTUS CONSTANTINI AUG. (fig. 32).[63] Thereafter, in Christian times, all coins show the emperor either draped or, preferably, cuirassed and armed and often helmeted. The military *virtus* of the emperor and the military costume have conquered heroic or divine nudity.

5) The evidence of the coins supports the observations of Professor Vermeule who remarks that the earlier imperial cult statues portrayed emperors and princes in divine and heroic guise rather than in armor.[64] In other words, there originally was an *imitatio deorum* on the part of the emperors and, before their time, on the part of the Hellenistic kings! The armored statues of so many gods seem to indicate the reverse current: an *imitatio imperatorum* on the part of the gods.

FIG. 32. Dumbarton Oaks, gold medallion: *Virtus Constantini*.

FIG. 33. British Museum, aureus (enlarged): Septimius Severus.

An *aureus* of Septimius Severus may illustrate this fact and lead on to some further observations (fig. 33).[65] The coin shows the sun god stepping on his chariot, the steeds ready to climb the sky which is indicated by cumuli of clouds arching over a *Tellus* who with her cornucopia rests comfortably reclined as though in an age of plenty and peace. The god, naked except for his fluttering shoulder cape is, however, not Apollo, but an Apollo sporting a pointed beard, that is, an Apollo having the features of Septimius Severus. The message of the coin is obvious. When the emperor rises (and his rise, *Oriens Augusti*, is a daily event like the rise of the sun),[66] the Earth, *Tellus*, is in a state of grace, of peace, and of comfort, in the state of a new felicity of a dawning Golden Age—*Tuus iam regnat Apollo* as visualized by Virgil in the Fourth Eclogue. Septimius Severus did not introduce the design. It is found on a *phalera*, a plaque serving as a decoration on the trappings of horses or of an armor,

emperor was shown even at an earlier date wearing the cuirass; see Alföldi, *op. cit.*, 47 f., with fig. 5.

[62] Delbrueck, R., *Die Münzbildnisse von Maximinus bis Carinus*, 27 ff., 100 f., 128 f., Berlin, 1940, who emphasizes that the bare-necked portraits (less rare after A.D. 260) referred above all to deified emperors.

[63] For specimens of these medallions, see Bellinger, Alfred R., Roman and Byzantine medallions in the Dumbarton Oaks Collection, *Dumbarton Oaks Papers* **12**: 125 ff., and figs. 7-11, 13-14, 1958; see also figs. 20 and 28 for Constantine's sons, and p. 132 for the description of the *Virtus* medallion (fig. 7).

[64] Vermeule, *Cuirassed statues*, 7.

[65] Mattingly, *Coins of the Roman Empire in the British Museum* **5**: 57, No. 226, pl. X, fig. 19 (A.D. 197). To this *aureus* in the British Museum Professor Andreas Alföldi obligingly called my attention, providing me at the same time with a photo.

[66] For this problem, see my forthcoming study *Oriens Augusti*.

now in the Vatican (fig. 34), and ascribed to the second century after Christ.[67] It is further found on a bronze medallion of Antoninus Pius,[68] and on two of Commodus.[69] While one of the Commodus issues clearly shows the youthful sun god, the other one shows the deity bearded like Commodus. The emperors in their nakedness thus indulged in an *imitatio deorum*. But the opposite trend, closely connected with the militarization of the imperial appearance, made itself felt as well. A relief from Ephesus of the time of Marcus Aurelius shows approximately the same scene.[70] Here, however, the person stepping onto the chariot is clearly the emperor wearing imperial

FIG. 34. Vatican, phalera: *Sol Invictus Augustus*.

[67] Guarducci, Margherita, Sol invictus augustus, *Rendiconti della Pont. Accadem. Romana di archeologia*, ser. 3, **30–31**: 161 ff., 1957–1959, tentatively dated the *phalera* second century. The inscription in the exergue reads: *Inventori lucis Soli invicto augusto*. See also Cumont, F., *Textes et monuments* **2**: 108, No. 89. I am again greatly indebted to my colleague Andreas Alföldi for a photo of this plaque.

[68] Gnecchi, F., *I medaglioni romani*, pl. I., fig. 6, Milan, 1912; *cf.* p. 16, No. 67. See also Toynbee, Jocelyn M. C., *The Hadrianic School*, pl. XIX, fig. 8, and p. 141, n. 5, Cambridge, 1934.

[69] Gnecchi, *op. cit.* (supra, n. 68), pl. LXXVIII, figs. 3–4, and p. 52, Nos. 3–4; Toynbee, *op. cit.*, pl. XIX, fig. 9.

[70] Heberdey, R., in *Jahreshefte des österreichischen archaologischen Instituts* **7**, Beiblatt 55 f., 1904; Reinach, S., *Répertoire de reliefs grecs et romains* **1**: 144, fig. 3; Paris, 1909; Mrs. Arthur Strong, in *Jour. Roman Studies* **1**: 39 f., pl. XII, 1911, and her *Roman sculpture from Augustus to Constantine*, 295, London, 1907; Toynbee, *op. cit.*, 141 and pl. XXXII, fig. 3.

FIG. 35. Dura-Europos: Zeus Theos.

uniform—the cuirass with metal *pteryges* and sash. The chariot is seen also in a wall-painting at Dura, in the shrine of Zeus Theos (fig. 35).[71] Here, however, the god, holding lance and globe, is not naked. He is dressed in Hellenistic-Parthian costume, the *paludamentum* held by a golden fibula on his shoulder. Actually, the sun god himself appears in full imperial dress, though not in military attire, for example, on a stele from Asia Minor, now in the Museum at Leyden (fig. 36).[72]

We notice that the *imitatio deorum* on the part of the emperors was supplemented by an *imitatio imperatorum* on the part of the gods. This principle of mutual imitation was actually carried so far that after the model of the imperial apotheosis (the emperor's ascent on an eagle) the gods in Egypt were "apotheosized" after the same fashion although as gods they were not in need of an apotheosis.[73] But the same idea is found in Syria as well where a tetradrachme of the third century shows the same design.[74] That is to say, the gods

[71] Rostovtzeff, *Dura-Europos and its art*, pl. XIII, facing p. 74; cf. Grabar, André, *Martyrium* **2**: 140 f., Paris, 1943.

[72] Leyden, Rijksmuseum van Oudheden, to which I am much obliged for providing me with a photo. The stele, as Professor F. K. Dörner kindly informed me, has been published by Cumont, F., in *Comptes-rendus de l'Académie des inscriptions et belles-lettres*, 270 ff., 1915; *cf.* Wikander, Stig, *Feuerpriester in Kleinasien und Iran*, 4 f., Lund, 1946.

[73] Vogt, J., *Die alexandrinischen Münzen*, 73 f., Stuttgart, 1924, calls attention to this apotheosis of gods; see also Cumont, F., in *Revue d'histoire des religions* **62**: 138 f., 1910.

[74] See, e.g., Bellinger, Alfred, *The Syrian tetradrachms of Caracalla and Macrinus* (Numismatic Studies **3**), pl. IX, fig. 2, New York, 1940.

FIG. 36. Leyden, Rijksmuseum, stele: Apollo and Artemis.

were treated as though they were emperors, and the emperors as though they were gods.

6) There is yet another argument which has been advanced to explain the military costume of so many gods in Egypt and the Near East, and this has to be considered seriously. It has been suggested that the military attire may have rendered many of the foreign gods, the *dii peregrini*, more acceptable[75] to the Romans who, as we know, often equated the foreign gods with their own, at least in name, though not always in substance. Hence, while the gods of the Roman Capitol were always represented as gods and not as officers, if we except Mars who professionally was often shown in military guise;[76] and while it would not have occurred to the Romans to put their own Jupiter into a uniform, it was different with the foreign gods. The *dii peregrini* were assimilated or romanized by means of their uniform, no matter whether the impulse may have come from the Orientals or from the Romans.

If we now review our arguments—(1) the late appearance of uniform military equipment; (2) the development of the cuirassed statues; (3) the development of the armored trophies; (4) the development of the cuirassed coin portraits of Roman emperors replacing the bare-necked portraits; (5) the interrelation of *imitatio deorum* on the part of the emperors and *imitatio imperatorum* on the part of the gods; (6) the tendency to romanize the *dii peregrini* by means of displaying them in military attire—we have a considerable number of clues at our disposal suggesting how it came about that so many gods of Egypt and the Near East were represented in uniform. Nor will it be really surprising to find that also the last of the oriental and foreign gods penetrating, and finally conquering, the Roman empire fell in with this general militarization and imperialization of the deities. Christ was repeatedly represented with the imperial purple chlamys around his shoulders, as, for example, in the ceiling-painting of the Roman tomb of Clodius Hermes, *ca.* A.D. 230;[77] that is at a time when also the expression *Christus Imperator* had become relatively common.[78] Even the victorious cross, taking the place of the pagan trophy, was sometimes decorated with the imperial paludamentum, which is found also as a special decoration of the pagan victory trophy the crossbeam of which, supporting the cuirass, may have produced some similarity with the *tropaeum Crucis* (fig. 37).[79]

[75] Will, E., *Le relief cultuel*, 270 f.: "pour les rendre acceptables."

[76] See, e.g., Vermeule, *Cuirassed statues*, pl. VII, fig. 24, for Mars Ultor in the Capitoline Museum, in Rome. On coins, of course, he is also very often in strictly military attire; see, e.g., Dattari, *Numi Augg. Alexandrini*, pl. IX, where Ares appears both in the nude (no. 2464) and cuirassed (no. 2460) in the times of Antoninus Pius (see above fig. 1 *a–b*).

[77] Wirth, Fritz, *Römische Wandmalerei vom Untergang Pompeiis bis ans Ende des dritten Jahrhunderts*, 190 and pl. 50, Berlin, 1934; tomb of Clodius Hermes (*ca.* A.D. 230), painting in the ceiling of one of the niches.

[78] See Peterson, Erik, Christus als Imperator, in his *Theologische Traktate*, 151 ff., Munich, 1951; also Kollwitz, J., Christus, *Reallexikon für Antike und Christentum* **2**: 1257 ff., 1954.

[79] See Baradez, J., and M. Leglay, La croix-trophée et le reliquiaire d'Aïoun-Berich, *Cahiers archéologiques* **9**:

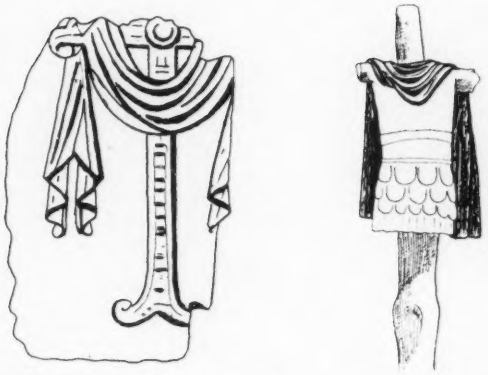

FIG. 37. Tropaeum Crucis and Trophy (North Africa).

Christ in military attire, however, is rather rare. A terracotta funerary plaque of early Merovingian times is too worn and its photographic reproduction too indistinct to control its editor's contention according to which Christ was represented in the costume of a Roman general holding a globe in his hand and stepping on the lion and the dragon.[80] It is quite likely, however, that the editor was correct. For in connection with Psalm 90: 13: "Thou shalt tread upon the adder and the basilisk, the lion and the dragon shalt thou trample under feet," St. Augustine, in his *Enarrations on the Psalms*, felt inclined to style Christ the *imperator;* and his commentary, through the agency of the ordinary Psalter gloss, remained influential throughout the Middle Ages.[81] This then may be the reason for the somewhat perplexing fact that the rare medieval representations of Christ as a warrior—*Christus miles* or *Christus belliger*—serve mostly, though not exclusively, as an illustration of this Psalm versicle. Christ in medieval armor is found, for example, in the ninth-century Stuttgart Psalter (fig. 38),[82] and also on the right end of the Hadelinus Casket in

FIG. 38. Stuttgart, Psalter: Ps. XC, 13.

Visé, of the late eleventh century (fig. 39).[83] In both cases the warrior Christ wears the purple chlamys, and holds in his left hand the book, in his right a lance or a staff; in the Psalter miniature he even wears the imperial shoes leaving the toes free.

FIG. 39. Visé, shrine of St. Hadeline: Ps. XC, 13.

77, figs. 2–3, 1957; for the problem in general, see Picard, Gilbert Charles, *Les trophées romains*, 494 ff., Paris, 1957, and Grabar, André, *L'empereur dans l'art byzantin*, 239 ff., Strasbourg and Paris, 1936.

[80] Lantier, Raymond, Plaque funéraire de terre-cuite mérovingienne, *Jahrbuch des Römisch-Germanischen Zentralmuseums* 1: 237 f., 1954, a study to which Miss Mary Morehart obligingly called my attention.

[81] Augustine, *Enarrationes in Psalmos*, XC, 5; Migne, *Patrologia latina* 37: 1163; *cf.* Kantorowicz, E. H., *The king's two bodies*, 71 f., n. 69, Princeton, 1957, for some later radiations.

[82] Stuttgart, Württembergische Landesbibliothek: Psalter, ed. Ernest T. DeWald, *The Stuttgart Psalter*, fol. 107v, Princeton, 1930.

[83] Baird, Alice, The Shrine of S. Hadeline, Visé, *Burlington Magazine* 31: 20 and pls. I–II, 1917; Helbig, J., *Art Mosan* 1: pl. facing p. 44, Bruxelles, 1906.

FIG. 40. Ravenna, Archiepiscopal Chapel: Ps. XC, 13.

The general pattern of these representations has its history. In the Archiepiscopal Chapel at Ravenna we find a mosaic picturing Christ, holding the book in his left hand and shouldering the cross-staff with his right in exactly the fashion in which Constantine (see fig. 32) carries the trophy. He stands on lion and dragon—not as *Christus miles*, but in the full and authentic uniform of a Roman *imperator* (fig. 40).[54] Over a long-sleeved tunic, he wears a golden cuirass with one row of small *pteryges* from which the leather flaps dangle, fringed at the ends. His shoulders are protected by similar leather tabs. His sash is hardly visible because most of his cuirass is covered by the purple *paludamentum*. The purple itself is fastened at the right shoulder by a round fibula framed by a circle of pearls or stones. From the fibula there dangle three long pendants

[54] Wilpert, J., *Die römischen Mosaiken und Malereien*, pl. 89 and p. 47, Freiburg, 1917. The lower part of the mosaic is restored, which, however, does not affect the present argument. Photo by courtesy of the German Archaeological Institute, in Rome (No. 58.559). See also Grabar, André, *L'empereur dans l'art byzantin*, 237 ff., and Lawrence, Marion, *The sarcophagi of Ravenna* (Monographs on Archaeology and Fine Arts **2**), 26, n. 130, 1945, for additional bibliography. See further Weigand, E., Zum Denkmälerkreis des Christogramm-nimbus, *Byzantinische Zeitschrift* **32**: 73 ff., 1932.

FIG. 41. Ravenna, San Vitale: Justinian.

composed of stiff golden pins ending in a large pearl each.

The fibula with three pendants of pearls is one of the foremost imperial insignia reserved for the emperors exclusively.[85] We know this insignia from the Madrid silver *missorium* of Theodosius I, where the emperor as well as his two sons and co-caesars displays the fibula with the three pendants,[86] and from the mosaic of Justinian in San Vitale at Ravenna (fig. 41).[87] Contrariwise, the imperial governor of Hermopolis, Aphrodisius, seen in the mosaic of the arch in Santa Maria Maggiore, in Rome, displays a fibula with no more than two pendants.[88] That is to say, Christ is represented in the correct uniform of a Roman general or rather an emperor, including the correct insignia.

The Ravenna mosaic of Christ triumphant over lion and dragon is the last representation of what may be called a god in uniform. It is true that

FIG. 42. Kariye Camii, Istanbul, wall painting: St. George.

[85] For the fibula, see Delbrück, Richard, *Die Consulardiptychen und verwandte Denkmäler*, text p. 40, Berlin, 1926–1929; Deér, Josef, *Der Kaiserornat Friedrichs II.*, 48 ff., Bern, 1952, with full bibliography, and Ein Doppelbildnis Karls des Grossen, *Forschungen zur Kunstgeschichte und christlichen Archäologie* 2: 111, 1953; see also Kantorowicz, *The king's two bodies*, 416, n. 341, for the later development.

[86] Grabar, *op. cit.* (*supra*, n. 84), pl. XVI; also, for the bibliography, Delbrück, *Consulardiptychen*, 235 ff., No. 62. For a better reproduction, see Deér, *Kaiserornat Friedrichs II.*, pl. XXIV, figs. 4–5, who (p. 49) for good reasons believes that the new type of the fibula with three pendants does not antedate Constantine the Great (*ca.* A.D. 315).

[87] The mosaic has been reproduced very often; see e.g., Grabar, *op. cit.*, pl. XX, fig. 1; von Simson, Otto G., *Sacred Fortress*, pl. III, Chicago, 1948; see also pl. XXVII, for the mosaic in Sant'Apollinare in Classe, where only the ruling emperor, Constantine IV Pogonatus, has the fibula with the three pendants, but not his sons Heraclius and Tiberius, although they, too, are haloed. For a third mosaic (of either Theodorich or Justinian), see von Lorentz, Fr., Theoderich—nicht Justinian, *Römische Mitteilungen* **50**: 333 ff., pl. LXIV, 1935.

[88] Wilpert, *Die römischen Mosaiken*, 489 and pls. 66–68.

FIG. 43 *a–b*. Venice, San Marco, relief: (*a*) St. George, (*b*) St. Demetrius.

certain saints, especially in Byzantine art, were uniformed even in later centuries, and their tunics sometimes reveal that they were enlisted in cadres of the imperial guards.[89] The two Saints Theodore (Stratelates and Tiro), Saint George, Saint Demetrius, Saint Procopius, and Saint Mercurius still appear in the late thirteenth-century frescoes of Kariye Camii, at Istanbul, in their traditional late Roman uniform (fig. 42),[90] and even in relatively modern (seventeenth- and eighteenth-century) Russian icons these saints are represented quite often in their quasi-classical military attire. Admittedly, their costume no longer is quite accurate and tends to become fantastic. But Saints George and Demetrius, in their relief icons of the west façade of San Marco in Venice (fig. 43 *a–b*), still show the correct armor of late antiquity and display the officer's sash tied in the Hercules knot.[91]

In the West, some saints were not only awarded knighthood, but received real army commissions, even in quite modern times. It was a paramilitary distinction when Saint Andrew of Amalfi was made a knight of the Golden Fleece by Philip III of Spain, a decoration which the saint actually wears when on his feast-day his statue is carried in procession through the streets of Amalfi. But it is far more startling when we hear that Saint Anthony of Padua, who died in 1231, was appointed in 1731, by Philip V of Spain, an admiral of the Spanish Navy with an admiral's salary, and

[89] Delbrück, R., Der spätantike Kaiserornat, *Die Antike* **8**: 20, 1932, indicates that the military saints wore torques, and that the trimmings of their tunics disclosed their attachment to various guard regiments; see also Treitinger, Otto, *Die oströmische Kaiser- und Reichsidee*, 51, Jena, 1938.

[90] Delehaye, H., *Les légendes grecques des saints militaires*, 2 ff., Paris, 1909; Underwood, Paul A., Fourth preliminary report on the restoration of the frescoes in the Kariye Camii at Istanbul by the Byzantine Institute, *Dumbarton Oaks Papers* **13**: 189, 192 f., 195, 197 f., 207, figs. 3, 4, 8, 10–14, 1959.

[91] Demus, Otto, *The Church of San Marco in Venice* (Dumbarton Oaks Studies **6**), figs. 40–41, Washington, D. C., 1960.

that the King himself decorated the saint's statue with the plumed hat of an admiral, with the bemedaled sash, and with a sword and a marshal's baton (fig. 44),[92] uniform insignia which the saint wore over his Franciscan cowl. A few years before that event, in 1710, Saint Anthony, a native of Portugal, had been appointed a general of the Portuguese army in the field.[93] In a way, he shared this high military rank with Saint Sebastian, who was a general of the Portuguese army in garrison.[94]

What was good for the mother country, was good for the colony, Brazil, where military honors were conferred upon Saint Anthony. By letter patent of 1751, Saint Anthony was commissioned a captain of infantry in the Brazilian army, captaincy of Rio de Janeiro.[95] This rank he held, with monthly pay of 4,000 cruzados and backpay of 540,000 cruzados, until 1810, when, by letter patent of October 25 of that year, he was commissioned a major in the Brazilian army with monthly pay of 36,000 cruzados. And finally, on July 26, 1814 he was promoted to the rank of lieutenant-colonel of the Brazilian Infantry. His salary of 80,000 cruzados monthly (*ca.* $40) was actually paid to him—that is, to a Franciscan convent in Rio de Janeiro—until 1911, when the Brazilian government revised all payments made to churches and monasteries. But the military rank of Saint Anthony was not forgotten. In 1914 the Austrian crack regiment, His Apostolic Majesty's Own Tyrol Rifle Regiment (*Tiroler Kaiserjäger*), went to war protected by Saint Anthony in the uniform of a Spanish Admiral, who had his cultual center in the Tyrol, in Innsbruck (fig. 45).[96]

FIG. 44. St. Anton, Innsbruck: St. Anthony of Padua.

FIG. 45. Admiral St. Anthony and the Tyrol Kaiserjäger (postal card 1914).

What was possible with regard to saints, both Eastern and Western, was not possible with regard to the Christian God. *Christus belliger* or *miles*, as has been demonstrated, was represented occasionally in the Middle Ages; but he wore individual armor, and not a uniform—simply because there were no uniforms in the Western Middle Ages. And when in the late seventeenth century uniforms again made their appearance—the Coldstream Guards for example, date back to King Charles II, and the papal Swiss Guard

[92] Kleinschmidt, Beda, *Antonius von Padua* (Forschungen zur Volkskunde 6–8), 358, and fig. 344 (p. 360), Düsseldorf, 1931. This study was most obligingly called to my attention by the Rev. P. Paul Grosjean, S.J., in Brussels, who readily provided me with additional information.

[93] Kleinschmidt, *Antonius*, 359.

[94] *Op. cit.*, 360.

[95] *Op. cit.*, 360 f., for the various promotions.

[96] *Op. cit.*, 356, fig. 341.

to the pontificate of Pope Julius II, while the design of their uniform is ascribed to Michelangelo —it no longer was possible or befitting to bestow upon the Christian God the rank of an honorary colonel of the Coldstream or Grenadier Guards or of the Irish Guards. Hence, the late-classical idea of representing gods in the correct military attire with the insignia of rank ended in the Ravenna mosaic of Christ defeating the lion and the dragon.

How are we to explain the idea itself of picturing the gods in the uniform of officers or generals? It is difficult, of course, to give a satisfactory answer which would fit all circumstances. This much, however, may be safely said, that the cuirassed statues of Hellenistic kings and Roman emperors, the cuirassed portraits on coins, and also the display of arms and armor *per se* in the form of trophies shouldered by the emperor or serving as a decoration, all are features indicative of the prowess, the *virtus* of the person so represented or so honored. In a similar sense, the cuirass, the military attire of the gods may have served to indicate their prowess, their *virtus:* it was the *virtus* of the Dioscuri, the *virtus* of Horus, the *virtus* of Asklepius or of the oriental sun gods which, just as the *virtus* of the emperors, was to be made manifest by the uniform or armor—and finally the *virtus Christi imperatoris* defeating lion and dragon.[97]

Therewith this rapid survey contributes, if from an admittedly narrow angle, to a far broader problem; that is, to the problem of the survival and the continuity of pagan iconography in Christian garb, or to the problem of the transition from pagan Antiquity to the Christian Middle Ages. And this survival by transference is really all that this paper intended to demonstrate.

APPENDIX

Two fragments of *terra sigillata* from the Benaki Museum in Athens came to the author's attention only after the manuscript was ready for the printer.[98] Whether they are relevant to the problem discussed in the preceding pages will be difficult to decide. But since the two pieces are as yet unpublished, they may be edited here nevertheless whatever their value may be for the present argument.

The fragments (figs. 46 and 47) form the upper and upper right sections respectively of a rectangular dish of quite fine pottery characteristic of late Roman ware.[99] The dishes have a relatively high rim which on the top is broad enough for the display of ornamental figures produced by stamps.[100] Dishes of this kind are well known. They usually were imitations of silver dishes presented to, or by, the high officers of the Roman Empire, cheap copies fabricated *en masse* for and purchased by the ordinary citizen—so to say, paperbacks as compared to *de luxe* editions.[101] Those dishes could be round when copied after the model of silver *missoria*, or rectangular when copied after a rectangular dish.[102] Roman law mentions both and even discloses their technical name: *lanx quadrata vel rutunda*.[103]

The fragments of the Benaki Museum thus belonged to the type of *lances quadratae* made of pottery, and the similarity of their decorated rims as well as the identity of the design of the central pieces of which actually a third specimen is known,[104] make it clear that we are dealing with objects of mass production. The design of the center emblema shows two horsemen facing each other and holding their horses by the bridle, using for this purpose their far hands, that is, the right figure the right hand and the left one his left.

[97] Picard, *Les trophées romains*, 511 f.

[98] I am greatly indebted to Professor Howard Comfort, of Haverford College, who first called my attention to the larger fragment; to Professor M. Chatzidakis, Director of the Benaki Museum in Athens, for sending me a photograph not only of the larger fragment, but also of the smaller fragment hitherto unknown to me; and to Professor A. Alföldi, my colleague at the Institute for Advanced Study, for patiently giving me advice concerning many essential items. The fragments (Benaki Museum, photographs 3833 and 3834) were both bought, and probably found, in Egypt. The larger fragment (fig. 46) is 33 cm. long and 19 cm. high, the smaller one (fig. 47) 20 cm. long and 12.2 cm high. The rim is, in both fragments, 4 cm. high, and it is (in fig. 46) 5.3 cm. broad. The measurements of a third specimen (see n. 106), no longer existing, but reasonably well described, were for the whole dish: 45 cm. long and 37 cm. high; the rim was 2 cm. high and 5–6 cm. broad.

[99] For the dishes of that kind, see Wace, Alan J. B., Late Roman pottery and plate, *Bulletin de la société royale d'archéologie d'Alexandrie* **37**: 47–56, 1948, a study to which Professor Homer A. Thompson kindly called my attention.

[100] See Wace, 52.

[101] Wace, 54 f.; *cf.* Fuhrmann, H., Studien zu den Consulardiptychen verwandten Denkmälern, *Römische Mitteilungen* **55**: 92–99, 1940.

[102] Wace, pl. III, reproduces such a dish. Fuhrmann, 93, mentions that he intended to deal with these rectangular dishes on a later occasion, but he died before publishing that study.

[103] *Digest*, 6,1,6; *cf.* Delbrück, *Consulardiptychen*, 70, n. 250.

[104] See below, n. 106.

FIGS. 46, 47. Fragments of late Roman pottery dishes (Benaki Museum, Athens, Photos Nos. 3833 and 3834).

In their other hands they hold spears with a broad blade, the right figure carrying the weapon upright, the left one carrying it horizontally. These horsemen in counterposition suggest the Dioscuri who were represented over and over again in this attitude. The costume of the horsemen is richly decorated or embroidered, their sleeved tunics as well as their *paludamenta*. The trappings of their mounts, visible especially in the smaller fragment (fig. 47), are likewise quite rich, an unusual feature in representations of the Dioscuri even when displayed in uniform. More startling, however, are the Phrygian caps which both riders wear. We might be inclined to interpret these headgears as misunderstood *pilei*, the felt caps normally worn by the divine twins, and accordingly to identify the two horsemen as militarily overdressed Dioscuri.[105]

This identification, however, is defeated by the inscription running in two lines above the heads of the figures. It reads:

ORATIONIBUS SANTORUM PE
RDUCET DOMINUS.

The inscription is the same in both fragments, and it was the same also in a third specimen, found in 1860 by a French farmer in Algier, of which we have a good description but which no longer exists: "en l'absence du colon Nicollet, ses enfants ont cassé le plat," ends the report of the finding rather disappointingly.[106] The lettering itself is almost identical in both pieces if we except the 'S' in DOMINUS (fig. 47) which apparently was not properly rendered by the stamp and which has been added in a somewhat clumsy and crude fashion. The inscription is obviously incomplete, and we would expect some continuation in the lower section of the pictures; for to the beholder it should be revealed whom and whither *perducet Dominus* on the strength of the prayers of the saints. The whole phrase has a "liturgical" ring, and in fact there are numerous passages in the earliest Western sacramentary, the *Leonianum*, which might serve to supplement the inscription; for example: ". . . sanctorum deprecatione placatus [Deus] . . . [populum] ad sanctorum gaudia sempiterna perducat";[107] or ". . . nos ad caelestia regna perducens";[108] or ". . . ad misericordiam perducat aeternam."[109] It would seem most likely that some place of destination similar to those quoted was found in the lower section of the central image. Curiously enough, the continuation of the inscription was lacking also in the Algerian specimen,[110] and later editors of the inscription supplemented: *nos ad regna caelorum* with a question mark.[111]

However that may be, it is obvious that the two horsemen are not the Dioscuri, but Christian saints. Who are they? We do not know equestrian saints represented after the fashion of the twin gods. It is true, in the *Pistis Sophia*, a Gnostic tractate of the third century, mention is made quite often of the "Twin Redeemers" (σωτῆρες), but they are identified with the "Child of the Child" which obviously does not fit.[112] Other identifications of the Dioscuri with twin saints are either unconvincing or do not fit the image of the *sigillata* fragments.[113] Unfortunately, the pictures on the rim of the dishes do not offer a clue either. In the frieze of the larger fragment (fig. 46) we recognize in the center an *aedicula* (not upright, but lying on its left side) harboring a person. To the right and left of the *aedicula* are lions running in opposite directions similar to those found in a pottery *missorium* at Madrid and

[105] For the Dioscuri in military attire, see above, notes 2 and 5, and figs. 2 and 4.

[106] See *Revue africaine* **6**: 463 f., 1862. The finder gave a reasonably good description of his *trouvaille* to a local newspaper. His report was later reprinted by the editor of the *Revue africaine* whence it was passed on to scholarly works of epigraphy. See *Corpus inscriptionum latinarum* **8**: 9285, where also the report is reprinted. See further Monceaux, Paul, Enquête sur l'épigraphie chrétienne d'Afrique, *Mémoires présentés par divers savants à l'Académie des Inscriptions et Belles-Lettres de France* **12** (1): 308, No. 321, 1908; Diehl, Ernst, *Inscriptiones latinae christianae veteres* **2**: 487, No. 2499; Berlin, 1925.

[107] *Sacramentarium Veronese*, ed. Mohlberg, L. C., Leo Eizenhöfer, and Petrus Siffrin, 12, 16 f., No. 87.

[108] *Ibid.*, 72, 2, No. 551.

[109] *Ibid.*, 155, 10, No. 1218.

[110] *Revue africaine* **6**: 463 f.: "Où le Seigneur conduira-t-il? Probablement à la gloire, au combat, à la victoire." The finder thought that the two warriors were North-African Arians at war against the orthodox Christians.

[111] So Monceaux, followed by Diehl (above, n. 9).

[112] *Pistis Sophia*, ed. Carl Schmidt, *Koptisch-gnostische Schriften* **1**: 147 ff., and *passim*, Leipzig, 1905 (see index, *s.v.* "Zwillingserlöser").

[113] Harris, J. Rendel, *The Dioscuri in the christian legends*, London, 1903, is brilliant but evasive. Grégoire, Henri, *Saints jumeaux et dieux cavaliers* (Bibliothèque hagiographique orientale **9**), Paris, 1905, deals with triplets and not with twins. Kraus, W., Dioskuren, *Reallexikon für Antike und Christentum* **3**: 1134 ff., 1957, mentions Saints Peter and Paul, and Cosmas and Damian, as Dioscuri by transference, but these saints cannot be identified with the horsemen of the fragments. See, for the holy triplets, Jacques Moreau, Zur Passio der hl. Drillingsbrüder, *Jahrbuch für Antike und Christentum* **3**: 134–140, 1960.

elsewhere.[114] They are purely decorative, just as the amphora (also lying) to the right of the right lion. It would be tempting to interpret the lions as indicative of a *venatio* and the two horsemen as *venatores*.[115] But this meaning would not be supported by the pictures of the third specimen, the dish from Algier. According to the report of the finder of that dish, there were the figures of three men on each of the four sides of the rim, and the finder first thought they represented the twelve apostles, but gave up the idea because the twelve figures were all made of the same stamp. Moreover, there was, in the center of the upper rim, the figure of a child "holding in its hand an emblem in the form of a 'Y'," [116] that is, the *littera Pythagorae*.[117] Hence, for the interpretation of the horsemen the picture-friezes on the rims of the dishes do not yield a clue either.

There is one more item which demands our attention. Between the two horses is a stand or a table—the Algerian report says "an urn"—on the top of which something that looks like two leaves is plainly visible. Professor Alföldi suggested that the stand might be an agonal table on which the prizes are laid out, the rewards given as a symbol of victory. Among those prizes were not only crowns, but often also individual leaves made of gold or a few gold coins or medals.[118] Similar tables are quite often displayed on coins, especially of Nero.[119] We usually find on them a crown and an urn, whereas under the top of the table we recognize figures such as two sphinxes facing each other or two gryphons. On one specimen, however, there are apparently two horsemen, in this case the twins, who face each other.[120] If indeed there should be in the images of the *sigillatae* an allusion to victory, it might be advisable to supplement the inscription accordingly and add perhaps the words *ad victoriam sempiternam*.[121] The whole inscription, in that case, would read:

ORATIONIBUS SANTORUM PE
RDUCET DOMINUS
[AD VICTORIAM SEMPITERNAM].

It would mean that the orations of the military saints prompted the Lord to lead the faithful to sempiternal victory. Unless, however, an undamaged dish turns up in some other collection or museum it will be impossible to supplement the inscription correctly or even to understand the meaning of the pottery centers. The date of the *sigillatae* may be fourth century or early fifth. They seem to be characteristic of the age of transition from pagan antiquity to the medieval Christian world, and the equestrian saints in military costume, if saints they are, would be exponents of the same evolution.

[114] See, for the pottery *missorium* of the Museo arqueologico, in Madrid, Führmann, in *Römische Mitteilungen* **55**: pl. XII, 1940.

[115] In the *missorium* of Madrid is indeed one horseman, a *venator;* but his costume is very different from that of the fragments from the Benaki Museum. For the "moral" aspects of the *venatio*, see Grabar, André, *L'empereur dans l'art byzantin*, 57 ff., 133 ff.

[116] *Revue africaine* **6**: 463: "Un enfant, placé au milieu du rebord supérieur, tient à la main un emblème en forme d'Y."

[117] For the literature on the Pythagorean letter, see Theodor E. Mommsen, in *Jour. Warburg and Courtauld Institutes* **16**: 184, n. 1, 1953; see also his *Mediaeval and Renaissance studies*, 184, n. 26, Ithaca, 1959.

[118] Delbrück, *Consulardiptychen*, 70 ff., § 4.

[119] Mattingly, Harold, *Coins of the Roman Empire in the British Museum* **1**: pl. 45, figs. 3, 5–8, and p. 250 ff., Nos. 259, 264 ff., London, 1923.

[120] Paris, Bibliothèque Nationale, Cabinet des médailles, No. 10708, a photograph of which was kindly placed at my disposal by Professor A. Alföldi.

[121] *Sacramentarium Veronese*, 50, 4, No. 366.

SOMATOLOGY OF THE AYOM PYGMIES OF NEW GUINEA

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It is only since the beginning of this century that New Guinea has become an object of methodical exploration by European scholars. It is no wonder, therefore, that even today there are sections entirely unknown to white men. This is quite understandable to one who has become somewhat familiar with the peculiar landscape, as well as with the behavior of the native population.

It may seem surprising that anthropologists who, at the turn of the last century, had visited that largest island of the South Seas should also have assumed that there might be living there groups pygmy-like in stature. As the years passed by, such assumptions became more concrete, and one spoke freely of pygmy-sized natives inhabiting the three sections of New Guinea which at that time were under Dutch, British, and German rule.[1] Then, between 1909 and 1913 four pygmy groups were discovered: the Kamaweka, by C. G. Seligmann; the Tapiro, by C. G. Rawling; the Torricelli, by O. Schlaginhaufen; and the Goliath pygmies, by A. C. de Kock.

But in spite of repeated reports, no definite statements were forthcoming as to whether these dwarf-like natives were a true pygmy-like race, genetically different from the so-called Kanakas (Melanesians of New Guinea), or whether their low body height was environmentally conditioned, perhaps as a biological adjustment.

After the end of World War II, when New Guinea revived, I began to study the racial problem of these populations there that were tentatively termed "pygmies." It seemed to me that the natives in the region of Mount Ayom along the middle course of the Ramu River appeared the most promising for my investigation.

Their home district is identified by the Australian Government as a "restricted area" unapproachable to outsiders. I therefore should like to express my grateful appreciation to the authorities for permitting me to enter there freely in unhampered pursuit of my explorations.

Those small people whom I designate as "Ayom Pygmies," because it is about Mount Ayom that they roam, have never been systematically investigated although they have occasionally been sighted. The first to point them out was the German missionary Franz Kirschbaum (1926),[2] followed ten years later by Lord Moyne.[3] Neither of them hesitated to classify those natives as "pygmies" because of their short stature. Since the end of 1952, Australian officers have reconnoitered the Schrader Range in five brief surveys and summarized their observations upon the native population in their Reports. From these I gained much valuable information. On May 30, 1956, I set foot on New Guinea, which abounds in mysteries of all kinds.

It is only in summer that one can move about without too much effort on the Schrader heights. In the remaining seven to eight months of the year heavy and continuous rains prevail, which confine even the natives to their huts. The climatic conditions there have thus considerably limited my own exploratory work, which partly explains why I had to restrict my efforts to the study of the natives of the Asai and Simbai Valleys. These two populations are somatologically and culturally related to the natives of the Jimi Valley. Although each of these three divisions speaks its own language, I am unable to say whether these differ only dialectically or linguistically. The Jimi Valley natives are quite unapproachable and hostile to any stranger who comes near them and their dwellings. Nevertheless, some time after my departure from New Guinea, a patrol officer of the Aiome Patrol Poste succeeded in penetrating the Jimi Valley. The methodical exploration of this almost unknown group

[1] As heretofore, the term "pygmy" is employed in the sense of Martin, R., *Lehrbuch der Anthropologie*, 2: 160, Jena, 1928; namely as a metrical category, i.e., the average male stature below 150 cm., and not as a racial type.

[2] Kirschbaum, Franz, Ein Neuentdeckter Zwergstamm auf New Guinea, *Anthropos* 22: 202–215, 1927.

[3] Moyne, Lord, *Walkabout, a journey in lands between the Pacific and Indian Oceans*, London, 1936; Moyne, Lord, and Kathleen Haddon, The pygmies of the Aiome Mountains, Mandated Territory of New Guinea, *Jour. Roy. Anthrop. Inst.* 66: 269–290, 1936.

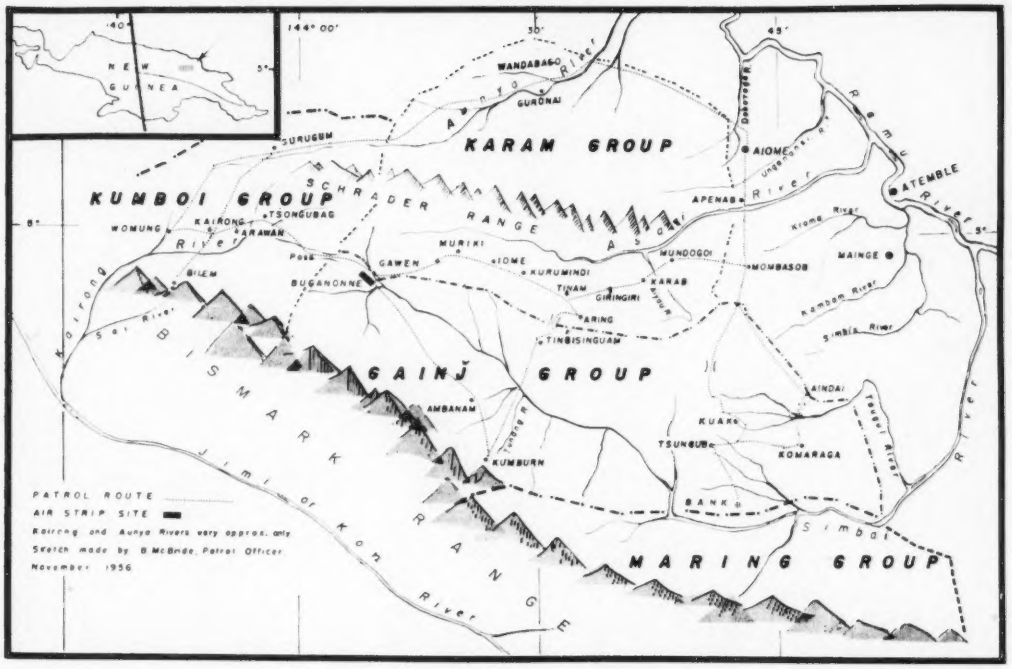

FIG. 1. Territory of the Ayom Pygmies.

must, therefore, be regarded as an urgent task in anthropological [4] research.

My trip to New Guinea was made possible through the financial aid of the American Philosophical Society which has likewise published my first report,[5] which I gratefully acknowledge herewith. My gratitude goes also to the friendly patrol officer Mr. Harry Halloway and to the Catholic missionaries working there, and finally to many official and private persons.

1. CONDITIONS OF LIFE

As already mentioned, the following report occupies itself only with the natives of the Asai and Simbai Valleys, which adjoin one another, although of their neighbors in the Jimi Valley the same observations may be true. Since all native populations depend more or less completely upon their habitat, that of the Ayom pygmies may first be briefly described and then followed by a description of their ways of living in that area.

The Schrader Range, the highest elevation of which, Mount Ayom, thrusts 7,455 feet into the sky, extends along the northern border of the gigantic Bismarck Massif projecting abruptly and steeply toward the medial Ramu Valley. The living area of the pygmies lies approximately between 144° 30′ and 145° east longitude and 5° 10′ and 5° 35′ south latitude, and is filled by irregular ranges with deep-cutting valleys the walls of which are very steep throughout but afford extensive plateaus at their summits. Here, from 2,600 to 4,500 feet above sea level, the little mountaineers roam about. They avoid descending into the Ramu Valley because of the hostility of the Kanakas. Dense, humid, and perennially green forest covers the entire landscape, and it is only at the summits that wide open plains are found. The nights, without exception, are cool, but it is intensely hot during the middle of the day. For some hours after sunrise, heavy fog fills the deep valleys. Rain falls more or less copiously throughout the year, but during the rainy season

[4] Vogel, Alfred A., *Papuas und Pygmäen*, Zürich, Füssli, 1954. Earliest publication of some physical details and photographs of those natives.

[5] Gusinde, M., Somatological investigations of the pygmies in the Schrader Mountains of New Guinea, *Year Book Amer. Philos. Soc.* for 1954: 270–275, 1958; A pygmy group newly discovered in New Guinea, *Anthrop. Quart.* **30**: 18–26, Washington, D. C., 1957.

FIG. 2. The author with a Simbai man.

proper in colossal amounts. The seasons of the year can hardly be distinguished one from the other.

The mountain region is appallingly poor in game, as well as in vegetal produce to support the pygmy-like natives. Many centuries ago, so I was told, their ancestors lived in the valleys where game and fish, as well as vegetation, were plentiful. Now the pygmies in their mountain retreats gather all sorts of provender like berries and nuts, fruits and mushrooms, soft green leaves, and particularly the so-called insect fare, namely, worms and caterpillars and their larvae. However, all these items are only of occasional use and do not represent sufficient nourishment. Hunting is almost out of the question. After they had been forced out by the invading Kanakas, there was and still is no other way out of this serious dilemma for the pygmies except for the women to garden intensively. These natives are now planters raising yam and taro, and of late, although in a limited way, also sugar cane, bananas, and sweet potatoes, so that now they are considerably relieved of their previous economic restriction as food-gatherers.

FIG. 3. Women from Karab.

Pottery being unknown to them, they prepare the edible raw materials by either roasting them in hot ashes, steaming upon heated stones, or boiling them in water in heavy bamboos. Their natural beverage is water; condiments and spices are not used. They furthermore lead a somewhat sedentary life, since the women cannot live far away from their gardens.

The huts of these little people on Mount Ayom are low, substantial, roundish structures with conical roofs, suitable for a couple and their children. All adults and older children wear loin cloths only, apparently for decency, very much in contrast to many Kanakas, who remain completely naked. Ornaments of various kinds and materials are likewise used, the men wearing heavy wigs. Of special interest is the fact that these people do not make stone implements and thus live under alithic conditions. Only of late have they acquired flat stone blades from which they manufacture regular axes.

Their social life is without any grouping and distinction in family lineage or occupational status, and there is no difference between rich and poor, there are no chiefs or leaders, magicians or priests. Monogamy is the rule, a dissolution of the marriage unthought of, the more so if there are children. It is only in recent years that two "progressive" young men, conscious of their own importance and imitating the Kanakas, have taken a second wife in marriage. Within the bounds of the family, man and wife are equals from the legal point of view, while the individual families live peacefully together without special ties or obligations to one other.

Everyone is the owner of what he finds, pro-

duces, or acquires. The garden belongs to the family and is attended principally by the wife and mother, occasionally assisted by husband and children.

The children, both male and female, are obliged to undergo the traditional rites of puberty.

I have not been able to learn anything outstanding about the spiritual life of the Ayom pygmies, since I did not succeed in recording their languages, and they themselves had no knowledge of pidgin English. I did not observe any signs of totemism, magic, or fetishism. Their untroubled minds and cheerful dispositions manifested themselves over and again during my extended sojourn with them. In their communal life, the Ayom people are peaceful; quarrels between families or family groups are quite rare. In their unfriendly, barren environment and under hard living conditions for old and young, one day follows the other. This brief description of the customs and living conditions of the pygmy natives of the Schrader Range characterizes their culture level and applies in a general way also to the so-called foodgatherers in other parts of the world.

The total number of pygmies, so it seems to me, has been greatly overrated at the present time by the patrol officers. My own estimate would be 2,500, equally divided among the three valleys mentioned. In their "restricted area," these pygmy-like natives have never come in continuous touch with Europeans, and the majority of them have never seen a white face. Small wonder therefore that, at first, most of the natives in those mountainous abodes behaved in a very shy and reserved manner and, even though after a short time I had somewhat gained their confidence, small groups of women and older men remained in their unapproachable hiding places during the entire time that I lived with them. Others were so terrified when they saw my anthropological instruments that they shrieked and rebuffed any attempt to take their body measurements.

In my somatological investigations likewise I had to cope with considerable handicaps, in that the individual families in the wide Mount Ayom area lived far apart from each other; furthermore, they showed themselves quite unyielding when I invited them to places where I had established myself with my belongings, scientific and otherwise, and for that reason I was able to secure somatological measurements from only 137 men and 66 women. But of those subjects I can say with assurance that they were of true Ayom stock without any admixture of Kanaka blood. From the very start I excluded from my investigations subjects of doubtful racial origin and pure-blooded Kanakas who only a few years ago had infiltrated the Schrader Mountains. I also excluded children, since it was impossible to ascertain their ages and hence separate them into age groups. I might add that in my measurements I followed R. Martin's instructions.

Since in a previous publication,[6] I have already described at length the topography and climate at Mount Ayom, the living habits and conditions of its pygmy-like inhabitants, their relations to the Kanakas of the adjoining plains of the Ramu River, and finally my own experiences with those unique little people of the Schrader Range, I shall now confine myself to the essential features of the somatological picture in its entirety.

II. PHYSICAL APPEARANCE

The German missionary Franz Kirschbaum (1926) and the English Lord Moyne (1936), who were the first to publish a number of definite and decisive characteristics of the body form of the Mount Ayom natives, emphasized the fact that in both body form and physical appearance these little people afford an entirely different impression from that of the Kanakas. My own experience conforms exactly to theirs. Spontaneous appraisals like these merit special attention, since they come from experienced and critical men. Thanks to his good fortune, Kirschbaum, at G. Edelbach's farm on the middle course of the Ramu River, came in contact with some of these little people, whose racial peculiarities he immediately recognized as different from those of the Kanakas, and whom without hesitation he designated as "pygmies" or "dwarfs." The Melanesian porters in his party concurred with him and, to quote him, he wrote (p. 207):

> My reason for naming the people whom I was visiting "Pygmies," lies in their low body height. . . . It was everybody's impression, including that of my native helpers from the coast who showed astonishment about the "children" . . . who were small, hardy and well developed individuals and by no means emaciated or malformed in their appearance. . . .

Lord Moyne, too, has fundamentally and correctly adjudged the little natives of Atemble at the middle course of the Ramu River as an independent type, although two factors have some-

[6] Gusinde, M., Die Ayom-Pygmäen auf New-Guinea, ein Forschungsbericht, *Anthropos* **53**: 497–574, 817–863, 1958.

FIG. 4. Men from Yuwamb.

what obscured his statement. One of these is the occurrence of transitional body forms between the Kanakas and those of the mountain dwellers. It will be shown further on that, in the past, miscegenations have indeed occurred between the Kanakas of the valleys and women of the Schrader Range. The other factor was Lord Moyne's observation that each group used certain implements (bows and arrows, for example) which could hardly be distinguished from those used by the other.[7] Lord Moyne, like Mr. Wanchope, the owner of another palm plantation on the middle Ramu River, accepted the view that two distinct races occupied the area. Writing about Mr. Wanchope, he says: "Traveling through the mountains he found that the foothills at his right were inhabited by people of ordinary stature and very dark skins. The higher ground at his left was occupied by a pygmy people of a very different type with light skins" (p. 274). Furthermore Lord Moyne had observed the hostile relationship between the two groups, a situation of by no means rare occurrence in New Guinea. He writes: "The natives of Atemble were afraid of venturing into the pygmy country."

Regarding the conditions just described, I had the same experiences. When, coming from Alexishafen on the north coast, I alighted from the airplane in front of the large office building in the Ayom Patrol Poste, I was immediately surrounded by a joyously turbulent crowd of Kanakas who pressed upon me in such a manner that I could hardly keep my equilibrium. After some time, when the pilot demanded the unloading of the plane, these vivid children of nature calmed down, and the throng gradually dispersed. I was now free to see a small group of little men who, apart from the Kanakas, stood closely together. Although the latter continued their boisterous shouting of joy, the isolated group remained rigidly silent like intimidated onlookers, ready to vanish quickly at any given moment. Quietly I forced my way through the Kanakas' throng jokingly and amicably, just as if they were old friends, and thus came inadvertently close to the group of the little men. Reassured by my smiles, they did not object to petting and caressing, until finally their stern facial expressions suddenly brightened up and their apprehension was gone, and they knew that there was nothing to be afraid of. While distributing little tokens among them, I studied, casually but critically, their faces and bodies. They are indeed of a type quite different from that of the Kanakas! This sudden and decisive recognition came upon me like a veritable revelation.

It is remarkable that Europeans in general who first come into contact with the pygmy-like natives of the Schrader Range react in a similar fashion. Still more remarkable, however, is the fact that the Kanakas consider themselves widely separated from the natives of the mountains, racially as well as culturally, with the emphasis on the racial difference, while the pygmies in turn look at their neighbors as different people and unlike in physical appearance. These attitudes are illustrated in many an idiomatic expression in the languages of both groups and reflected likewise in the contrasting conditions and ways of living of the two groups.

1. THE BODY FORM IN GENERAL

It will be my task now to discuss the racial difference between the Ayom pygmies and the Kanakas of the valleys. But these two groups are in no

[7] Lord Moyne failed to interpret correctly the two phenomena mentioned as a result of bartering between the two neighboring populations. The correct explanation may be found in M. Gusinde, 1958: 550 (see footnote 6).

way as different as, e.g., the pygmies of the Eastern Belgian Congo and the Negroes around them, or the Aëta of the Philippines from the Malays. The natives of the Schrader Range are at once distinguished by the uniformity of their decidedly low stature, and this character alone removes them definitely from the Kanakas, although it represents only one of the distinguishing traits of their total habitus, which is marked by a moderately strong and muscular body. There is nothing that might indicate a heavy or clumsy skeleton, and nowhere, not even along the much exercised lower extremities, are protruding muscles or muscle groups in evidence. Palpation of the muscles of arms and legs in the men indicates an extraordinarily hard muscle tissue which seems only slightly softer in women. Subcutaneous fat deposits are not entirely lacking, at least not in the buttocks, and this helps, particularly in younger females, to round out and smooth their body surfaces. Really obese men or women I have not encountered. Women of middle or advanced age become rather lean, and in individual cases, even "parchy." This clearly is an indication of the serious lack of fat in the food of the Ayom people, as well as of the insufficiency of the food itself.

When these little people stand or walk, their carriage is almost rigidly erect and, when carrying a heavy load, well-nigh an everyday duty of the women, the entire upper body is bent forward. A band of a hand's breadth, fastened to a long carrying bag, is placed upon the forehead while the real weight of the load rests upon the lower region of the back.

When the men are sitting in their preferred attitude, the buttocks rest on the ground, the knees being bent and drawn toward the forwardly inclined upper body, while the arms embrace the knees and the feet rest on the ground to their full extent. The women prefer to stretch out their legs full length on the ground, the clasped hands resting in their laps. For a change, but only occasionally, both sexes sit on the ground in such fashion that the legs with bent knees rest on the flat ground on their outer surfaces, the feet being crossed. In general, these natives choose a flat base to sit on, never a fallen tree or a stump, a rock or a chair.

In their nightly sleep, adults as well as children bend their bodies, so to speak, into a squatting position, and press their folded arms against their chests, changing their position occasionally from side to side. This attitude during sleep is conditioned by the limited space inside their huts, where at the same time everybody tries to be near the comforting warmth of the hearth.

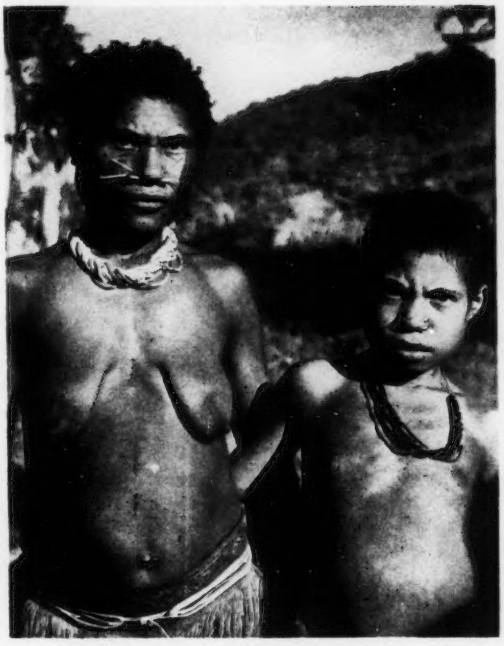

FIG. 5. Mother and daughter from Karab.

Men, almost without exception, carry a stick of a thumb's thickness slightly exceeding shoulder height which they loosely grasp with both hands, but do not use as a support in mountain climbing; apparently it serves only for ornament. In walking, both sexes take only short steps and touch the ground with the entire soles.

To ascertain the stature of the men was difficult in a number of cases, because they are proud of their wigs, which at times are tightly attached, and persuasion was necessary to get them to remove them for a short while. They then behaved as if their heads were severely chilled; their own hair was usually wet from perspiration. Even during the night, these wigs, which are reinforced by a kind of bast surface for tight fitting, are kept in their places.

The stature average for 137 men came to 1,448.3 mm., and for 66 women to 1,402.9 mm., at ranges from 1,294–1,510 mm. for the former, and from 1,272–1,490 mm. for the latter. The sexual difference between the two averages thus amounts to only 45.4 mm., which is in accordance

TABLE 1

Body measurements (in millimeters)	Ayom-Pygmies				Kanakas	
	137 ♂		66 ♀		32 ♂	
	M	$v_1 - v_n$	*M*	$v_1 - v_n$	*M*	$v_1 - v_n$
1. Body height (stature)	1448.3	1294–1519	1402.9	1272–1490	1551.9	1461–1651
4. Suprasternal height	1209.6	1100–1288	1162.8	1047–1247	1281.4	1207–1343
5. Omphalion height	867.3	779–944	826.9	713–903	935.4	871–983
6. Symphysion height	754.0	685–818	720.7	633–776	798.8	736–848
8. Acromion height	1208.3	1092–1282	1162.0	1040–1259	1281.4	1199–1368
9. Radiale height	927.8	856–1027	893.9	827–958	983.3	923–1046
10. Stylion height	707.4	646–768	688.0	621–737	745.4	700–799
11. Dactylion height	539.2	480–595	527.9	470–568	562.6	524–600
13. Iliospinale ant. height	829.2	766–904	794.0	722–864	880.5	824–971
15. Tibiale height	390.3	322–440	370.0	313–406	415.5	382–448
16. Sphyrion height	47.5	41–57	46.6	37–56	53.1	46–58
17. Arm stretch	1563.4	1429–1672	1435.4	1238–1588	1663.4	1526–1776
23. Height in sitting	716.5	621–788	702.4	651–753	777.5	730–834
27. Trunk length	455.5	400–506	442.2	390–479	482.6	451–536
35. Biacromial diameter	315.9	288–536	288.0	262–320	331.6	300–356
36. Transv. diam. of chest	226.6	193–253	209.9	198–233	235.3	203–257
37. Sag. diam. of chest	169.7	144–200	162.5	143–189	176.5	160–193
37a. Sag. diam. of belly	177.5	144–226	182.7	161–213	177.1	160–193
39. Breadth of waist	220.4	195–248	210.9	183–233	235.2	199–252
40. Iliocristal diameter	232.6	211–254	234.1	214–258	249.3	233–277
41. Iliospinal diameter	167.4	146–187	167.5	143–203	182.2	154–202
43. Conjugata externa	159.3	140–183	162.6	140–180	169.6	150–189
45a. Length of arm	669.2	574–722	633.5	528–719	718.8	654–770
49. Length of hand	168.2	144–193	160.2	136–188	182.8	158–204
51. Length of middle finger	95.6	83–111	92.5	78–106	103.1	96–114
52. Breadth of hand	74.3	63–83	68.9	62–79	79.8	69–86
53(1) Length of leg	774.0	724–838	740.6	653–815	833.8	761–873
58. Length of foot	225.3	206–251	210.6	190–230	241.5	224–262
59. Breadth of foot	84.7	70–96	78.6	64–92	91.3	81–99
61. Girth of chest	797.6	715–882	743.7	690–820	853.8	774–914
62. Girth of waist	739.9	649–841	704.9	632–774	765.0	674–834
65. Girth of upper arm	225.0	180–264	199.3	171–236	249.7	209–295
67. Girth of forearm	138.6	121–162	127.0	112–144	149.2	134–166
68. Girth of thigh	432.9	365–489	436.4	373–535	436.4	392–496
69. Girth of calf	293.2	230–335	281.1	254–320	320.5	290–363
71. Total weight (lbs.)	92.3	69–118	84.7	66–105	110.7	92–130

with the drastically low body height of these people. The greatest frequency for men lies between 1,460–1,479 mm., and for women between 1,400–1,419 mm. The frequency curve of stature distinctly demonstrates this sexual difference, which may be seen in other peoples throughout the world and, amounting to 45.4 mm. between the averages in our case, equals 3.2 per cent.

There need not be any concern over the fact that among the 137 males of our group, 18 of them exceed the conventional stature of 150 cm. for pygmies, since this figure represents an average derived from a range of variation which may contain extreme individual values without changing the ethnic status. On the other hand, the frequency chart descends as low as 1,294 mm., so that the total range covers 216 mm. None of the women reach 150 cm., although two come near to it.

As mentioned above, the individual families are only thinly settled at the summits of the high walls of the valleys or upon the adjoining open spaces of the Schrader Range. I had chosen as temporary stations four of these localities, at various altitudes, and thus investigated four separate groups. Gradually advancing from the lowermost station, which is the district of Mombasoh and Aigram, there follows that of Karab, Mundogoi, and Gormend, and further on that of Ngiringiri, Tinan, and Grai, and finally, closer to the headwaters of the Asai and Simbai rivers,

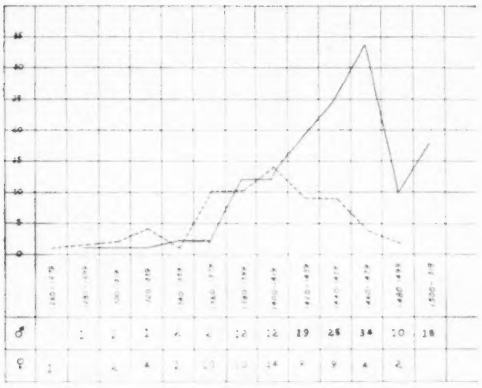

FIG. 6. Frequency curve of stature.

that of Gainj, and of the Simbai Valley itself. Since there is no striking difference in the average body heights in either male or female of the four groups, it did not seem worth while to account for either group separately.

It may be added here that I have also measured 33 men of the small Kanaka villages at the foot of the Schrader Range. Their average stature was 1,551.9 mm. ranging from 1,461 to 1,651 mm., which exceeds that for the Kanakas at the middle course of the Ramu River by 103.6 mm.

According to anthropological standards for the body heights of human varieties, the Ayom people are pygmies.* The low stature of those natives, a feature which becomes more outstanding when representatives of the two groups, the mountain and valley dwellers, accidentally stand together, surprised the two above-named explorers, Franz Kirschbaum and Lord Moyne.

Lord Moyne-Haddon writes (p. 172):

> We visited a pygmy woman, 4 feet 2½ inches in height, who had married a Melanesian man of Atemble four years previously. The two men [from the Schrader Range] measured 4 feet 6 inches and 4 feet 9 inches, respectively. They were of an entirely different type from the [Ramu] River natives. Nearly a foot shorter in average stature, they were of a strongly contrasted color, being light brown, while their neighbors at Atemble were very dark.

Finally, Mr. Worcester, the patrol officer of the central Ramu Valley, emphasizes in his Second Report (1954): "The build of these [Asai] people is lighter and shorter than the average Ramu native, but they are by no means pygmies." That this officer acknowledges a considerable difference between the two racial groups may suffice for our purpose, although his concept of "pygmies" is quite contrary to my own.

In comparing the lengths of the various body divisions in their entirety, their concordance will be noticed in the aggregate. One might even say that their definitely shorter dimensions reflect a proportion, approximating that of the average European. The head in relation to the low body height, frequently appears somewhat thick and large, even excessively large, since for reasons of fashion many men and women wear a kind of wig over their own copious crop of hair, as will be described in full below. In studying the physical appearance of our Ayom pygmies, at-

* Schmitt, Emil, Die Grösse der Zwerge und der sog. Zwergvölker, *Globus*, **87**: 121–125, 1905.

TABLE 2

Ayom Pygmies				
Body height	137 ♂	66 ♀	absol. difference	diff. in %
	1448.3 mm.	1402.9 mm.	45.4 mm.	3.2
Weight	108 ♂	43 ♀	absol. difference	diff. in %
	41.8 kg.	38.3 kg.	3.5 kg.	8.7
Twides				
Body height	510 ♂	382 ♀	absol. difference	diff. in %
	1440.3 mm.	1370.4 mm.	69.9 mm.	4.9
Weight	226 ♂	202 ♀	absol. difference	diff. in %
	39.8 kg.	35.5 kg.	4.3 kg.	10.8

tention may be diverted by these head ornaments. The proportions in general will impress him as quite normal.

Weight likewise is seen in proper relation to the low stature. It averaged 92.3 pounds (41.8 kg.) in the 108 men, and 84.7 pounds (38.3 kg.) in 43 women, the ranges of variation reaching from 69 to 118 pounds (31–53 kg.) in the former, and from 66 to 105 pounds (30–48 kg.) in the latter. The weight thus differs by 8.7 per cent between the sexes in favor of the male. For the sake of comparison it may be added here that the medium body weight of 30 Kanaka men of the central Ramu Valley was 110.9 pounds in a range of 92 to 130 pounds, showing them to be 18.6 pounds heavier on the average than their male neighbors of the Schrader Range.

2. TRUNK AND EXTREMITIES

In proportion to the low body weight of the Ayom natives, their necks are quite short and only moderately thick. The outline of the neck, starting from the head, continues to the shoulders in a mildly concave curve. The shoulders slope somewhat in the men, but are more horizontal in the women. I have not seen a single case of goiter or "Adam's apple."

In both sexes the trunk is of rectangular shape, as shown in the two transverse diameters of chest and pelvis (crestal breadth), of which the first yielded averages of 232.6 mm. and 234.1 mm. in the two sexes. The trunk in its entirety impresses one as rather vigorous, moderately high, moderately broad and, compared with the length of the legs, medium in length. The latter proportion by no means approximates that found in the eastern Twides about the Ituri River (Belgian Congo)[9] with their surprisingly short legs. The anterior wall of the trunk is more or less plastically differentiated in the Ayom men where for example the pectoralis major muscle is quite distinctly marked. In some middle-aged men a narrow margin around the nipples protudes considerably, while the nipples themselves look like buds seen in young girls. Such a plasticity of the anterior wall of the chest is indicative of arms frequently used in hard labor. Muscle contours of the chest and abdomen are not distinguished in women, because the panniculus adiposus in the anterior trunk wall is but meagre in either sex. In spite of this the impression prevails that the Ayom people are moderately well nourished and fairly strong, while in their senile years the abdominal walls are flabby and wrinkled. A somewhat heavy or even full abdomen is not met with. In multiparous middle-aged women, however, a slight bulging of the lower abdomen remains which in later years gives way to flat integumental folds a finger's breadth in width. In certain subjects the lateral walls of the lower abdomen bulge slightly over the iliac crests.

The upper border of the trunk is represented by the shoulder height (acromion) and by the upper rim of the manubrium sterni (suprasternale). In both sexes the suprasternale height exceeds very slightly that of the acromion. As to the absolute dimensions, the height-in-sitting (measurement 23), as well as the anterior trunk height (measurement 27), of the males somewhat exceeds that of the females; as to the relative measurements of the trunk height, those of the females slightly exceed those of the males. This condition however repeats itself in the majority of human varieties. Furthermore, comparison of the acromion-breadth (breadth of shoulders) in both sexes reveals that the males, with 315.9 mm., range above females by 288.0 mm., a proportion which likewise holds true for the breadth of "taille" (breadth of waist), namely, 220.4 mm. and 210.9 mm. in the sexes. However, this difference, from the sexual point of view, is not so decisive that it reflects in the build of the trunk in both sexes the marked distinction which prevails in other human varieties. When, furthermore, it is observed that in both sexes the "taille" of the adults bulges mesially to a very slight extent, it becomes quite evident that the shape of the trunk differs only slightly in either of them. In this connection the sagittal chest diameter with male and female averages of 169.7 mm. and 162.5 mm. is somewhat more definite.

I have likewise taken the sagittal abdominal diameter (depth of abdomen, measurement 37 (3)) in order to show that the voluminous "Trommelbauch," which in the Ituri pygmies of the Eastern Belgian Congo is a persistent trait, is not encountered in the Ayom people.

As already mentioned, the breadth measurements of the trunk, including the important bicrestal breadth, show distinctly that the difference between the sexes in this respect is quite insignificant.

This is also true for the navel, which in both

[9] An explanation of the term "Twides" may be found in Gusinde, M., *Die Twiden, Pygmäen und Pygmoide im tropischen Afrika*, 21 sq., Wien, Braumüller.

sexes is of medium size, transversely oval to roundish.

Examining the dorsal aspect, it is difficult to distinguish between a male and a female, since both show a certain rectangular contour of the trunk and only a slight mesial bulging of the waist, while above the sacrum the lordosis is only weakly expressed. In about 50 per cent of the females, as also in a number of males, distinct lateral lumbar fossulae were to be found. The dorsal (spinal) furrow is shallow throughout. The buttocks are non-voluminous in either sex, and, although sexually conditioned, more voluminous in middle-aged women than in men of the same age.

Because of the absolute shortness of the trunk, the impression obtains that in the female the mammae lie somewhat high. These organs develop as in general from a budlike breast to a shallow saucer-like form, while during and after pregnancy they assume a goat-udder shape resembling a flat skin-sack.

Further details regarding the shape and size of the breast and trunk of the Ayom people may be had from the absolute measurements listed in this report. Judged by their bodily appearance alone, it is truly astounding what intense physical effort they are capable of exerting.

As already mentioned a number of times, the ratio between the body-weight and the sitting height with respect to the upper and lower extremities does not differ much from human conditions in general as shown by the absolute, and still better by the relative, measurements. Arms and legs display strong muscularity in the males, proving, in addition to the low body height, that both pairs of extremities are in frequent and forceful use. The various circumferences of the arms and legs remain within moderate bounds, since adipose as well as muscular tissues are likewise only moderately developed, with the result that even the females lack the typical voluminousness of the thighs and buttocks. With the flexing of the muscles of the arms and legs, one notices their unusual hardness and compactness.[10] The hands of the men are coarse and bony; those of the women, in spite of their heavier daily chores, remain neat and comely, but they flex hard and are dry in either sex. Strangely, the typical X-shaped long leg bones of the females were not observed; bowleggedness does not occur. Both sexes are prevailingly right-handed.

In measuring the length of the lower extremity in man, a somewhat intricate procedure, R. Martin (1:165) recommends (measurement 51 (1)) adding 35 mm. on the average to the symphysial height. But in consideration of the pygmian stature of our Ayom people, I have added only 20 mm. to the adult measurement, a procedure duly emphasized herewith.

Any footgear, even the simplest sandals, is unknown to our mountain dwellers; they remain barefoot throughout life. The bare feet appear large in both sexes, although they do not widen excessively toward the toes. All toes, including the big ones, are set loosely one against the other without leaving spaces between neighboring toes. In standing and, without exception, in walking, the adult natives turn the longitudinal axes of their feet slightly inward. The soles of their feet are almost entirely flat, suggesting flat-footedness. The women, particularly in walking, touch the ground with the entire soles of their feet oriented horizontally, which makes their movement somewhat clumsy. This very probably is the result of the women's daily chores of carrying heavy loads on their backs and, in consequence, bending their bodies forward.

Both the fingernails and the toenails are thick and hard, and mostly rectangular in shape. They are never cut and hence break irregularly while the natives are at work.

Because of its complexity, one cannot ascribe great importance to the arm-stretch measurement relative to the body measurements in general, although it does contribute to the plastic conception of the human figure in general. In the Ayom population, with but few exceptions, this measurement exceeds the body height. Comparing the averages of stature and arm-stretch reveals an excess of the latter over the former by 115.1 mm. with a sex difference of 32.5.

3. HEAD AND FACE

Any one meeting our pygmian Ayom natives for the first time finds their heads crowned with thick wigs which give them an odd appearance, for the disharmony between low stature and voluminous headgear violates all sense of symmetry and proportion. The little natives themselves are deeply devoted to their make-up. Only after long months of wear do they relieve their heads

[10] On this Lord Moyne comments briefly (p. 176): "The muscular development was very varied. Some had very sturdy legs and buttocks such as might be developed by climbing on steep ground."

FIG. 7. Simbai man.

for a few days, either to re-arrange the decorations or to renew them altogether. Almost continuously the men endure the great heat which permeates their crop of hair under the tight-fitting bast hood and suffer a rather torturous sleeping position so as not to damage the wigs. Women allow themselves relief from this torture more frequently than do the men and for longer periods of time; many of them renounce the wearing of wigs altogether. Fortunately there was adequate opportunity to observe and examine metrically the shape of the heads in both sexes.

For many an observer the *heads* of our mountain dwellers may seem a little too large in proportion to their general appearance. This, however, is more or less illusory. It depends, for a first impression, upon the angle of observation from which a stranger views the Ayom men. If he himself is tall, or is standing on a higher level, the body proportions of the person under observation become distorted, since such parts of the body as lie nearer to the eyes of the observer impress him as being larger than they actually are. When one looks, therefore, down upon our little men, their heads appear more voluminous than when observed from the same horizontal plane. Anthropologists, however, can and must rely upon absolute and relative measurements which indisputably disprove the illusory appearances. The phenomenon, indeed, is repeated with regard to our natives of the Schrader Range. One is, however, justified in stating that the size of their neurocranium exceeds that of their splanchnocranium, and even more so in men than in women. The average cephalic measurements gave 182.0 mm. for the length and 175.4 mm. for the breadth; 139.0 mm. and 133.6 mm. in the sexes. Comparing these two absolute measurements with those of the eastern Twides (Belgian Congo), it is surprising that in the latter they turn out somewhat higher. Women in the two populations compared here have slightly smaller heads than men. In the cephalic length-breadth index, both sexes of the Ayom people are closely alike and are closely related to the eastern Twides. The Ayom natives are distinctly mesocephalic, but near the borderline of dolichocephaly. On the other hand, the Twides have a larger horizontal cephalic circumference, and altogether the heads of the so-called "classical" pygmies of the Ituri forest are absolutely and relatively larger than those of our natives of the Schrader Range.

As regards the length-auricular height index, our natives stand exactly at the beginning of the long list of hypsicephalic races, namely, with indices of 63.75 and 64.14 in the sexes, indicative of high neurocrania.

The measurements presented here emphasize to some extent the shape of the head of these dwarfish people, whose horizontal contour is prevailingly longitudinally oval. A median-sagittal (longitudinal) cephalic arc beginning above the forehead at the hairline reaches its highest point in a flat curve and continues rounding down to the inion. A flat occiput with lateral margins does not exist. The forehead is broad and either rises straight or recedes slightly until, after a sharp bend, it continues toward the hairline. The latter at times descends farther down upon the forehead, causing the lowest hairs to cover the backward inclination of the median-sagittal curve. This broad, high, and in most cases, vertically rising forehead bounds the cutive face superiorly in a surprisingly marked fashion. It is further enhanced by well-developed superciliary arcs, although no torus supraorbitalis was observed.

The averages for the *minimum frontal breadth* are 102.7 mm. and 100.2 mm. in the sexes, indicating a forehead of medium breadth. Between the medial ends of the eyebrows are two nearly vertical furrows of 15–25 mm. in length which

TABLE 3

Head measurements (in millimeters)	Ayom-Pygmies				Kanakas	
	137 ♂		66 ♀		32 ♂	
	M	$v_1 - v_n$	*M*	$v_1 - v_n$	*M*	$v_1 - v_n$
1. Head length	182.0	169–193	175.4	165–185	186.7	180–196
3. Head breadth	139.0	129–150	133.6	124–144	142.0	130–154
4. Frontal breadth	102.7	93–114	100.2	94–107	107.5	99–123
5. Biauricular breadth	126.2	113–139	121.5	112–131	128.8	119–137
6. Bizygomatic breadth	132.1	122–144	125.2	114–136	136.9	122–150
8. Bigonial breadth	102.2	89–116	97.3	88–105	104.4	96–120
9. Interocular breadth	32.8	28–39	32.5	28–38	35.0	30–42
10. Ext. biocular breadth	87.0	80–97	84.6	77–92	90.6	82–96
11. Eye breadth	27.2	22–32	26.0	21–30	27.8	22–33
13. Nasal breadth	41.7	36–53	37.7	32–43	44.0	36–53
14. Oral breadth	52.2	44–60	49.2	42–58	54.7	43–63
15. Auricular height	115.9	103–133	112.5	98–124	119.3	112–128
17. Physiogn. facial height	164.4	140–188	155.9	141–170	171.9	159–189
18. Morphol. facial height	109.1	92–124	102.5	92–110	114.8	105–126
19. Nasion-stomion height	75.8	65–89	70.6	61–80	80.0	71–91
20. Nasion-prosthion height	68.2	60–84	64.9	57–73	71.6	64–80
21. Nasion-subnasale height	52.5	44–64	49.7	41–56	56.2	47–64
22. Pronasale-subnas. height	14.0	10–20	12.8	9–17	15.6	11–19
22a. Nasion depth	19.6	14–26	17.4	10–21	19.9	16–24
25. H. of mucous lips	15.7	8–23	15.1	9–23	18.1	12–24
26. Subnasale-stomion height	22.3	16–29	20.5	16–26	23.8	19–30
29. Physiognom. ear length	56.6	46–65	51.7	46–60	59.8	50–68
30. Physiognom. ear breadth	35.9	31–43	34.1	29–39	36.9	32–42
31. Tragion-tuberculare l.	30.3	21–37	28.9	24–33	31.7	27–37
32. Morpholog. ear breadth	50.6	43–59	48.2	42–57	51.7	42–57
45. Horiz. circumf. of head	533.2	501–563	512.5	478–543	542.0	525–591
48. Nasion-inion-arch	358.7	318–386	340.8	298–392	361.4	322–395
49. Transverse head arch	325.5	297–362	317.4	293–349	323.1	299–349

bound a skin area of 10–20 mm. in breadth. This integumentary area ends at the level of the nasofrontal suture, above which a well-distinguished horizontal wrinkle runs from one medial angle of the eyelids to the other. These insignificant lines give an expression of seriousness to the faces of the Ayom people. A few transverse furrows are noticed in the foreheads of middle-aged people which, with advancing years, become further emphasized by deepening and may even reach the temples.

From the racial point of view, the details so

TABLE 4

Tribes	Head length		Head breadth		Length-breadth index	
	♂	♀	♂	♀	♂	♀
Ayom Pygmies	182.0	175.4	139.0	133.6	76.43	76.13
Eastern Twides	184.3	177.5	141.9	136.9	76.99	77.22
Ramu Kanakas	186.7	—	142.0	—	76.06	—
Tribes	**Nasal height**		**Nasal breadth**		**Nasal index**	
	♂	♀	♂	♀	♂	♀
Ayom Pygmies	52.5	49.7	41.7	37.7	79.84	76.11
Eastern Twides	43.3	40.5	44.7	41.1	103.79	101.85
Ramu Kanakas	56.2	—	44.0	—	78.63	—

far mentioned, with those to be described below, give the Ayom people an entirely individual *shape of the face*. Compared to their low stature, the face impresses one as medium large, even though metrically it is small. The upper as well as the lower third of the face is longer than the shorter middle portion. Preponderantly the contour of the entire face is moderately broad to broadly oval, in some cases even broadening into an angular pentagon, while in women it becomes somewhat oval. The profile again demonstrates the high and straight forehead, a large nose, and an almost straight lower face with only slight prognathy in individual cases.

Three breadth measurements of the face of our natives are somewhat larger in men. These are the *bi-auricular*, the *bizygomatic*, and the *bigonial* breadths. The first one yielded male and female averages of 126.2 mm. and 121.5 mm. respectively, while the second exceeds the first with 132.1 mm. and 125.2 mm., showing the greatest breadth of the middle face to be in the zygomatic region. The bigonial breadth, finally, with male and female averages of 102.2 mm. and 97.3 mm., distinctly demonstrates the diminution of the lower facial breadth dimension.

Of the measurements of the *facial height*, the physiognomic may be mentioned first. Since this measurement lacks osseous determination, there is to be observed a wide range, namely, 140–188 mm. in males and 141–170 mm. in females. The averages, however, give the usual deviation, namely, 164.4 mm. and 155.9 mm. in the sexes. The height of the face in our natives of the Schrader Range is lower than a first impression suggests. Its averages of 109.1 mm. and 102.1 mm. in the sexes belong at the bottom of the list for all human varieties. Here likewise the individual measurements show considerable range: 92–124 mm. in men and 92–110 mm. in women. The low mid-facial height is further emphasized by the nasion-stomion height with averages of 75.8 mm. and 70.6 mm. in the sexes. From these values, in combination with the moderate facial breadth, only a low morphological face index can be expected. Our natives are indeed euryprosopic, with averages of 82.54 in the males and 83.03 in the females.

These conditions conform to the bizygomatico-nasal breadth index with averages of 32.06 and 30.37 in the sexes; they express the presence of broad noses on the broad faces of our pygmies.

The *orbital cavities* are distinctly marked by their strong osseous supraorbital margins, which make it seem that the eyes lie quite deep. The palpebral fissure, averaging almost identical breadths of 27.2 mm. and 26.0 mm. in the two sexes appears spindle-shaped and opens moderately widely. The lateral orbital commissure lies about 2–3 mm. higher than the medial one. The sclera is never purely white, since it contains numerous dark spots and colorings from a delicate yellow to a light brownish hue. The iris is of a deep to darkish brown without much variation. The eyelids are thin and upon the medial third of the upper lid is frequently seen a clearly noticeable integumental fold which extends downward to the palpebral margin. The Ayom men have a staring look that impresses one as sullen and diffident. Their eyes move restlessly as though on the lookout for threatening perils.

Particularly because of the low middle face, the *nose* appears rather too voluminous for the medium-sized face, an impression which the absolute measurements perhaps do not too clearly reveal. The averages for the nasal height (nasion-subnasale) and nasal breadth (Martin: measurement 13) yielded 52.5 mm. and 49.7 mm. for the former, and 41.7 mm. and 37.7 mm. for the latter, in the sexes. From these two dimensions the indices on the average are 79.84 in men and 76.11 in women, thus falling in about the middle of the mesorrhine types (70.0–84.9).

The length of the nasal base (measurement 22: nasal depth pronasale to subnasale) measures the projection of the tip of the nose from the face, which on the average is 14.0 mm. and 12.8 mm. in the sexes. An additional measurement (22*a*) [11] is concerned with the depth (retreat) of the nasion at the upper end of the nasal height, which helps to define the size and projection of the nasal complex in profile view. The averages amount to 19.6 mm. and 17.4 mm. in the sexes, which slightly exceed the length of the nasal base.

The contour of the nose at the base describes

[11] In this procedure a special instrument is used consisting of two parts which are connected with one another at right angles. The head is oriented in the ear-eye plane and at right angles to it, a 20 cm. long flat wooden strip is made to touch the tip of the nose; this is provided with a horizontal, sliding and anteriorly pointed metal ruler with millimeter divisions. This ruler is then pushed toward the nasion parallel to the ear-eye plane. The so-called depth of the nasion thus equals the horizontal projective distance between the nasion and a vertical indicating the tip of the nose, while the head is in ear-eye orientation.

TABLE 5

Body indexes	Ayom-Pygmies 137 ♂		66 ♀		Kanakas 32 ♂	
	M	$v_1 - v_n$	*M*	$v_1 - v_n$	*M*	$v_1 - v_n$
a. Trunk length: Body height	31.46	28.77–34.56	31.53	29.00–33.55	31.11	27.99–33.86
b. Height in sitting: Body height	49.48	44.75–53.55	50.17	44.75–53.68	50.11	46.68–52.75
c. Length of arm: Body height	46.19	41.58–50.07	45.14	41.51–46.77	46.31	44.16–47.66
d. Length of leg: Body height	53.48	50.13–57.74	52.78	50.62–54.74	53.08	51.20–55.46
e. Length of arm: Trunk length	147.09	128.95–169.34	143.38	128.95–157.83	149.16	136.81–168.60
f. Length of leg: Trunk length	169.83	145.05–197.17	167.41	154.84–189.53	170.48	155.12–198.84
g. Length of arm: Length of leg	86.48	79.95–93.67	85.46	77.42–91.24	82.27	84.20–90.93
Head indexes						
a. Ceph. length—Breadth I.	76.43	69.31–82.86	76.13	69.72–81.55	76.06	70.16–82.80
b. Ceph. length—Auricular h. I.	63.74	53.76–75.29	64.14	57.14–71.68	63.91	57.65–68.45
c. Physiogn. face Index	124.53	110.07–140.65	126.46	111.62–138.84	125.87	113.57–138.40
d. Physiogn. face Index (Broca)	80.50	71.10–90.85	80.49	72.02–89.58	79.75	72.25–88.05
e. Morphol. face Index	82.54	70.76–96.74	83.08	73.84–87.70	83.96	75.71–92.48
f. Jugomandibular Index	77.33	67.52–91.87	77.75	71.88–85.00	76.29	70.63–86.07
g. Bizygom.: Nasal breadth I.	32.06	26.62–40.77	30.37	25.00–38.91	32.16	26.47–39.20
h. Nasal Index	79.84	63.33–100.00	76.11	61.11–100.00	78.63	61.67–94.00
i. Physiognom. ear Index	58.30	53.33–75.00	64.16	55.17–74.51	61.96	55.56–74.51
k. Morpholog. ear Index	168.06	134.29–242.86	167.25	135.48–188.89	163.82	127.03–196.43

a moderately broad triangle, in a number of men even a pentagon, and in these cases the nose itself is rather voluminous with rounded corners. The nose is prevailingly funnel-shaped with a straight or slightly concave bridge or one moderately broad. In many women the shorter nasal bridge is more concave, producing what might be termed a "Knopfnase" (bulb or knob nose). In cases like these, the nasal base rises noticeably anteriorly and the tip of the nose is tilted slightly upward, but retains its horizontal position without exception. In no case has a convex nasal ridge, i.e., a hooked or aquiline nose been observed, although it frequently occurs in the Kanakas. The nostrils are longitudinally roundish; the nasal wings are never puffed. A moderately deep integumental furrow running transversely above the nasal roof and rising slightly above the level of the medial palpebral commissures of the eyelids impresses one as quite broad, the averages amounting to 32.8 mm. and 32.5 mm. in the sexes.[12] A more or less heavy integumentary right and left fold which, beginning where the osseous and cartilaginous parts of the nose meet, is, in men, never lacking, but in women it is never seen. Each one of these folds slants down the cheek and fades away below the zygomatic bone. Altogether they lie a little higher than the nasolabial folds which are frequently seen in other groups outside the Ayom people. Medially situated, they occur likewise in the Kanakas.

Slight prognathism has already been mentioned. The integumentary *upper lip* with height averages of 22.3 mm. and 20.5 mm. in the sexes bulges slightly forward in most cases, while in others it runs straight and somewhat slopingly downward. A shallow broad filtrum is never missing. The only moderately-to-medium thick mucous membrane of the lips shows height averages of 15.7 mm. and 15.1 mm. in the sexes; they are of a bluish-brownish thick mucous hue, being neither rose nor red. The under lip in general appears somewhat thicker and pendulous. The margin of the upper lip is indistinct, but forms a

[12] Quoting Lord Moyne (p. 175): "The noses generally were straight and broad, the roots being clearly marked. The ends of the nostrils were not square and not diagonal, the bulbs being made to stand out by a bird's quill or as many as four fine sticks cut from the fronds of a sago-palm and worn right through the septum. About three shorter sticks were generally set in the nostrils at various angles diagonal to the bridge. These fine sticks reminded one of a cat's whiskers."

double arch. The oral fissure is moderately broad, but the large and frequently broadly rounded chin is distinctly shaped.

4. INTEGUMENTAL ORGANS

Although the integumental organs are easily accessible to direct observation, it is quite difficult at times to describe their exact condition. This in particular applies to the human *skin*. Although preponderantly a protective organ for the human body, it is more directly under external influences than the body coverings of animals (wool, hair, feathers, scales). On many primitive peoples wearing only scanty apparel, cold, heat, wind, and sun work much more drastically than upon animals. Fat depletion, dryness, keratogenous irregularities, discolorings of the epidermis, exposure to the smoke of the fires inside the huts, and, finally, mechanical injuries of various kinds are frequently varying conditions subject to local and climatic influences.[13] Regular and total ablutions with soap and water are rare among the primitives; consequently greasy and salty waste material from their integumental glands, dirt and soot are deposited upon the body surface, causing pathological conditions of the skin without, as a rule, impairing the organism as a whole. Most primitive native populations thus do not possess a clean, healthy or normally functioning skin.

More readily distinguished than structural changes of the skin are those of color. However, sun tanning in the tropics differs somewhat during the rainy season from that of the dry season, and the following remarks about the Ayom pygmies in this respect are general. In older persons there is something like a slight intensification of coloring, while more decided fluctuations obtain in younger people. Then there are certain individuals who, more than others, expose themselves to the smoke inside their huts. The degree of coloring of the adults closely resembles No. 29 of v. *Luschan*'s "Hautfarbentafel," although on the whole it is slightly darker. It may perhaps be clearer to state that the skin color of Ayom people lies between the deep dark of the Melanesians and the lighter color of the Papuans, but without any brownish nuance. This appraisal was arrived at by observation of people who, while drawing water, occasionally seized the opportunity for a thorough cleansing, or who had been marching a long time in heavy rain.[14] In general the skin of these pygmies appears smooth and taut, wrinkles becoming more incisive only with advancing years.

A man of the Gainj group of about thirty-five years of age showed a considerably higher degree of coloring than the average. His face and neck, however, were of a light ivory yellow. The forehead areas usually covered by wigs were still lighter and looked bleached. The iris was of very light, but impure gray, apparently a symptom of partial albinism.

As to be expected, every person possessed a repellent skin odor, more intense under physical work and stress, and especially while dancing in the crowded interior of a hut, when almost the entire body becomes moist, although the hands remain nearly dry. A number of times I have also observed tiny drops of perspiration upon forehead and body, but never all-over sweating. When occasionally the sweat would run copiously off my own body, the natives seemed quite surprised.

Our Ayom pygmies have a moderately strong growth of hair over their entire bodies, the individual *hair* being thick and stiff, ulotrichous, according to Hutley's classification. The hair of the head is loosely curled in its natural structure, but more tightly so after reaching a certain length. In general the hair is black, but more frequently so in women of any age than in men. The freely extending isolated terminal portions of the hairs appear slightly reddish or have a reddish brown shimmer. In three youthful individuals the body and head hairs were more or less naturally reddish blond, but not of the Nordic kind, and no indications of albinism were present. The hairs gray slowly, but I never observed complete whiteness. The adults let their hair grow for months on end, which produces a dense hair crop, because the individual hair tufts intermingle with one another. This hair crop is protected by a light bast hood which may be simple or made up of two or three layers; it generally fits tightly and may be held in place by strings or strips of bast.

[13] Lord Moyne (p. 174) indeed seems to have been quite perplexed by these conditions, for he writes: "Nothing could exceed the filth of their bodies. Several had ringworm and such was the accumulation of dirt and dead skin even on those free from this complaint that it was difficult to be sure of their exact colour."

[14] The patrol officer Worcester reported (1954) of the Asai people: "Skin colouring varies from light to dark brown. There are no really black complexions in the area." It is quite probable that in his specific areas he encountered many a mixed-blood. See also Gusinde, 1958: 518.

There can be no doubt that this "hair-do" simply serves decorative purposes; it does not protect against rain, for the bast hood easily transmits it. Our natives do not require any protection from the dense fogs or low temperatures which prevail for several weeks of the year, for they are quite hardened against the weather. However, the bast hood causes certain definite annoyances in that (p. 399) it intensifies heat and humidity. Many men, and occasionally women also, enlarge these hair decorations into monstrous wigs with quite sensational effect. Do they, perhaps, seek to create a menacing impression to counteract the inferiority complex resulting from their pygmian stature? The hair decoration is not an invention of their own; truly artful specimens of this kind are created by many a Kanaka tribe of the central highlands.

Our pygmies, to achieve their ends, need for their purpose a coherent hair growth, either from their own or from other heads. Formerly, if sufficiently voluminous, they scraped it off with a sharp mussel shell; nowadays rusty razor blades are used which work faster. Such a loose hair cap they pull over their heavy crop. He who can afford it even uses a second such cap, covering everything, including the ears, with the light bast hood already mentioned a number of times, while broad bast strips tautly applied in various directions over this artful contraption keep it in a fixed position. In the nooks and niches they stick bird feathers, blossoms, plant fibers linked together in little chains, and other striking embellishments. This voluminous head gear stays fixed even during lively hopping dances, despite the numerous dangling ornaments. Its size and bulk are apparently the pride of the younger men, who gladly undergo the discomfort of sleeping with their heads in an uncomfortably high position in order not to disarrange their towering head gear. One has to be cautious, however, not to misjudge the situation. Actually for a number of years the popularity of this head gear has been declining, and some young men have begun to reject it with contemptuous comments.

FIG. 8. Man from Mombasob.

The razor blade just referred to is of late more and more frequently used by the Ayom men in the weekly removal of their sturdy beard hairs, which indeed thrive luxuriantly in all men and seem to be quite burdensome to them. Full beards I have observed only sporadically in men of the Asai and Simbai Valleys. Nowadays the beardless face is the fashion. But formerly these men knew how to get rid of their beards by rubbing the juice of a certain herb into the areas of beard growth. This loosened the hair roots, enabling them to be plucked singly with the nails of the thumb and middle finger. Graying of the beard occurs very late and only sparsely, after at least half of the head hair has already grayed.

Lord Moyne (p. 175) has generalized these conditions quite fittingly, pointing out that "they had bushy eyebrows and upcurving eyelashes and some had much hair on their faces, chiefly on the chin. I noticed one with bushy black whiskers, another with a grizzled and bristling beard and moustache."

Starting at the continuous hair line above the forehead, they scrape and scratch the hairs away over a breadth of one or two fingers, as well as those upon the adjoining hair fields lying below the newly produced hairline of the forehead, with the result that only the hair on top of the head, i.e. above the upper margin of the ear, remains undisturbed.

The copious crop of hair of youth may thin out in a very few aged individuals, but never develops into baldness. In aging women a peculiar integumental stripe pattern on the sinciput

region may be seen over which runs the two- to three-fingers-wide ribbon of the supporting hair sack, but here the hairs are merely fewer; they are never entirely lacking.

The *ear* of the Ayom pygmies exhibits no irregular features. In its upper half the auricle is broadly oval. In the very rare cases of short ear-lobules, these are never freely pending, but attached to the integument.

The physiognomic ear lengths attain averages of 56.6 mm. and 51.7 mm. in the sexes, demonstrating the prevalent microtic picture. The physiognomic ear index comes to 58.31 and 64.16 in men and women.

The ears, situated at medium height, are closely proximated to the head, a condition further exaggerated in men by the constant pressure of bast hood or wigs. Mutilation of the ears is not practiced by our natives.

It was especially enjoyable for me to observe daily for many weeks the magnificent *dentition* of our Ayom people. In no other primitive people have I seen such regular and beautiful teeth. In sharp contrast there came frequently to my mind the repulsive mutilation of teeth in the Eastern Twides, a very detestable practice indeed.[15] What surprises one most favorably in our pygmies is the even and brilliant brightness of the ivory-colored enamel of the teeth, the relatively large size of the incisors in men, the medium size of the teeth in both sexes, and their perfect and regular arrangement in a medium-broad horseshoe-like dental arch. In either jaw the teeth are closely set without gaps, and only in very rare cases do the incisors and canines protrude beyond their cutting edges. Among the 260 persons of various ages twelve cases of caries were observed in the molar region. From early youth the teeth are very frequently used by every one in many manipulations to complement the work of the fingers. Altogether I have seen six male individuals whose first or second incisor tooth was damaged because of too strenuous use. The majority of elderly people still have their healthy, ivory-colored, and faultlessly placed teeth, for whose care they do absolutely nothing. Alveolar prognathism in a very slight degree is the general occurrence. When biting, as well as when both jaws are inactive, the vertically placed upper incisors "over-bite" the lower ones very slightly.

[15] See Gusinde, M., Urwaldmenschen am Ituri, 147, Wien, Springer, 1948.

This brief characterization of the typology of the Ayom people may suffice. Because of their low stature they must be considered *true pygmies* in anthropological terms. The question now arises: are there other physical features in which they differ from the Kanakas? The Melanesians of the middle course of the Ramu River who live in close proximity consider themselves racially distinct from the small types of the Schrader Range. Their male stature average of 1,551.9 mm. exceeds that of our Ayom pygmies by 103.6 mm. (See tables of measurements.) There are likewise differences in the body proportions, skin and iris color, and the fingerprints in particular reveal peculiar patterns by which our Ayom people differ from all the other native populations of New Guinea studied so far (see G. Geipel's summary).

In this respect I should not like to enter into a somatological comparison of our Ayom people with pygmian groups which have been studied in other parts of New Guinea. There is no uniform appraisal of those groups among anthropologists. H. Bijlmer, one of the most capable and reliable explorers, for example, writes as follows: "In my opinion the little mountain Papuans are no real pygmies; they are intimately allied

FIG. 9. Kanaka woman from Turubu.

to the Negritos but nevertheless they are true Papuans."[16] Lord Moyne (p. 181) differs with this opinion when he writes:

> The appearance of these little people [at Mount Ayom], so different from that of their neighbors or of any other natives whom we had seen in the Netherlands New Guinea, Papua or the Mandated Territory, surprised us, as we had expected to find a much more uniform type. . . .

Therefore, I do not yet dare definitely to assign the Ayom pygmies to their proper place in the classificatory scheme of the New Guinea natives.

To indicate tentatively, at least, where they might be placed, I point out the following significant phenomenon. In several areas far away from the coast, with equally secure and inconspicuous hiding places, small groups of low-statured people have been sighted. In addition, it is not unusual to observe certain adults in the Kanaka villages who have lived there since birth, and who are distinguished from their fellows by their pygmian stature and other widely different bodily features. The offspring of such pygmy-like individuals again show the accustomed racial traits of the Melanesian community. There is apparently a Mendelian process underway tending to suppress certain pygmian traits and to re-establish the dominant hereditary ones in the blood of a given population. These two briefly mentioned phenomena might be satisfactorily explained by the assumption that the primary settlers of New Guinea were a pygmian population which, consequent to the Melanesian invasion, fled into remote areas where they are still found, while other pygmy-like persons or small groups have mixed with invaders of other racial composition. This, then, is the reason for certain primary racial characteristics in their phenotypical state. With great probability our Ayom people may be considered biogenetically as a genuine pygmy tribe and hence racially different from the Ramu Kanakas.

It is well known that environment, in its largest meaning, changes body size, reducing it. Indeed, the height of the Ayom people does not exceed the limit of 150 cm., the average of the male half, which limit has been agreed upon for the classificatory system of human races, and under this consideration the Ayom are a pygmy group. However, in addition, other biogenetic facts must be submitted to prove their pygmy nature.[17]

FIG. 10. Kanaka woman with her children.

A study of the dermatoglyphics of the Ayom pygmies has been published by Geipel.[18] He concludes that the Ayom tribe is significantly distinct in the frequency distribution of most fingerprint characteristics investigated and is therefore genetically different from the African pygmies. The Ayom race is undoubtedly a Melanesian one even though decidedly different from Melanesians in general (e.g., the Kanaka).

The somatological data presented here distinguish the two divisions of low-statured natives of the Schrader Range who inhabit the Asai and the Simbai Valleys at least as a special racial type. It now appears urgent to explore the third group which racially and culturally approximates the two groups treated here, and which roves about in the Jimi Valley. Several months ago the Australian government established here a patrol post and an air strip; thus the Jimi people are now easily accessible to exploration. Let us seriously remind ourselves that so-called Western culture could easily play havoc in these regions and extinguish their aboriginal cultural heritage.

[16] Bijlmer, H., The pygmy question more especially in relation to New Guinea and its environs, *Proc. Pan-Pacific Sci. Congr., Tokyo, 1926* **2**: 2396, Tokyo, 1928.

[17] Just when this manuscript was sent to be published, A study of the population near Aiome, New Guinea, by L. T. Chamnesse a.O., appeared in *Oceania* **33** (4): 294–304, Sydney, June, 1960. It deals mainly with the investigation of blood groups among the natives near Mount Ayom. The opinion of W. W. Howells: The racial elements of Melanesia, *Harvard Univ., Peabody Museum*, **20**, 1943, and of other anthropologists concerning native groups considered pygmies in New Guinea will be discussed in a special article now in preparation.

[18] Geipel, G., Die Finger- und Handleisten der Ayom Pygmäen Neu-Guineas, *Ztschr. für Morphologie und Anthropologie*, **49**: 1–21, Stuttgart, 1958.

THE CONTROVERSY OVER THE SITE OF HEAT PRODUCTION IN THE BODY

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CHARLES-ROBERT RICHET, writing in the late nineteenth century, applauded Lavoisier's work on animal heat, particularly because Lavoisier was able to establish an analogy between a vital phenomenon and a chemical phenomenon, and was able to include precise instrumental measurements of the two comparable activities.[1] While praising Lavoisier for having demonstrated that "la vie est une fonction chimique,"[2] Richet noted that among the facts that escaped Lavoisier's notice, one of great importance was that the heat of the body was actually produced within the tissues and not in the lungs.[3]

The analogy between respiration and combustion carefully drawn by Adair Crawford[4] and Antoine Lavoisier[5] actually raised as many problems as it solved. The success in demonstrating that respiration and combustion generated the same amount of heat while producing the same amount of carbonic acid gas (or fixed air) led to the search in the animal body for the site of heat production, i.e., for the combustion within the living system of some substance similar to charcoal or a wax taper.

Lavoisier's mistake was not the choice of the wrong location for heat generation, but rather the assumption that the chemical process, combustion, would be repeated identically within the body. The once successful analogy when pushed too far called forth attempts to "save the phenomenon"; theories were proposed to account for a combustion which would not burn up the living tissues; analogues of the fuel which fed the fire were sought in the blood; and great efforts were made to determine where in the body the products of combustion were first formed. The problem of where the animal heat was generated was treated as a chemical problem. Only later did it become clear that the immediate questions to be solved were physiological ones.

If the problem of localizing combustion was the difficult one for Lavoisier, his predecessors had fared no better in their own efforts to deal with the heat found in the animal body. When the ancients posited an "innate" heat in the heart, their analogy forced them to find an additional process capable of moderating the heat and making sure that it did not consume the body. Thus, the function of respiration was believed to be the cooling of the heart. The late Hippocratic treatise, *On the Heart*, notes that this organ is protected "for it is comfortably enwrapped already by the lungs and thus surrounded it curbs the violence of the heat, for the lungs are naturally cool, but they are also cooled by inhalation."[6]

A similar view of the cooling action of respiration, probably originating with Empedocles and descending through Philistion, was enunciated by Plato and Aristotle.[7] In the *Timaeus*, Plato provides a detailed account of how the vital heat "about the blood and veins" is cooled by air from the outside which enters the lungs during respiration.[8] Aristotle adopted the theory of the refrigerating effect of respiration but also added that "nature has contrived the brain as a counterpoise

* Harvard University. This paper was read at the annual meeting of the History of Science Society, Chicago, December, 1959.

[1] Richet, Charles-Robert, Lavoisier et la chaleur animale, *Rev. Scientifique*, 3rd ser., **34**: 144, 1884.

[2] *Ibid.*, 145.

[3] *Ibid.*, 145.

[4] Crawford, Adair, *Experiments and observations on animal heat, the inflammation of combustible bodies. Being an attempt to resolve these phenomena into a general law of nature* London, 1779; 2nd edition, much revised, 1788.

[5] The analogy was first drawn in Lavoisier, Antoine-Laurent, Expériences sur la respiration des animaux, et sur les changemens qui arrivent a l'air en passant par leur poumon, *Mém. Acad. R. Sci.*, 185–194, 1777 (1780) and Lavoisier, Mémoire sur la combustion en general, *ibid.*, 592–600, 1777 (1780).

[6] Translation from Hurlbutt, Frank R., Jr., *Peri kardies*, A treatise on the heart from the Hippocratic corpus, *Bull. Hist. Med.* **7**: 1111, 1939.

[7] Cornfold, F. M., *Plato's cosmology*. The Timaeus of Plato translated with a running commentary, 284, 307, New York, London, 1952.

[8] *Ibid.*, 283, 284.

to the region of the heart with its contained heat." The brain, by combining the properties of earth and water, was able to cool and moderate the excess warmth of the heart.[9] For both of these philosophers respiration served primarily as a cooling agent, moderating a heat which might otherwise get out of control. For Galen, who compares the innate heat directly to a fire, respiration served to conserve the source of the heat by ventilating or fanning it, and also, by cooling it.[10]

The important question that each of these writers faced was the physiological one: how can a heat or fire be maintained in the body without causing it damage? As a matter of fact, the ancients constructed much of their physiology with this question clearly in mind. The reason why any group of animals has lungs, Aristotle suggested, is because "it is necessary to have some means for cooling the heat of the body; and blooded animals are so hot that this cooling must come from outside them." While land animals were air-cooled, the alternative method was adopted by the fish—water-cooling. Among the earliest theories of animal heat, the problem of how a process so similar to fire could exist in the body, was clearly recognized. A survey of subsequently proposed theories indicates that a new solution to the problem was not easily found.

William Harvey adopted an explanation for animal heat which was essentially the same as that proposed by Aristotle and Galen. "Large animals" he said, "are much warmer and breathe frequently, because they have need of greater cooling and ventilation inasmuch as they very greatly abound in blood and heat."[11] Thus, in Harvey's view animals filter their blood through the lungs so that the great heat of the liquid may be cooled, saving it from boiling and extinction.[12] The heat which Harvey considered "innate" resided in the blood itself, although it had its origin in the heart which he likened to a hearth.[13] The problem to be solved and the solution proposed were identical with those of the ancients; an "innate" heat was cooled by respired air.

Other seventeenth-century theories of animal heat, by proposing a fermentation which occurred in the blood as the source of warmth, avoided the problem of the super-heated heart. The proposals advanced by Van Helmont, Hooke, and Mayow had this and several other important features in common. They all denied the existence of an "innate" body heat, but relied instead upon a continuous process of chemical nature. The special function of the lungs and respiration was not refrigeration, but the supplying of the blood with that part of the air necessary for the fermentive process. The production of heat occurred throughout the blood system of the animal; the blood passed through the lungs simply to acquire something from the respired air.[14] The heat-producing process did not take place in the heart alone. If it did occur, as had previously been thought, in the left ventricle only, Mayow inquired, how was one to explain that in the fetus the blood bypasses that chamber and moves directly from the right ventricle to the aorta?[15] In another conjecture Mayow sought to explain why so intense a heat is generated in the muscles during exercise. Casting aside the suggestion that it was caused by friction of the bodily parts, he proposed that it was due to the same sort of process already described for the blood. He added that since the heart itself is a muscle, its continual action was probably responsible for the "vital" heat which the ancients attributed to that organ.[16]

The challenge to the theory of the heart as the source of an "innate" heat was given substance by Borelli's direct thermometric measurements. He opened the thoracic cavity of a live animal and encountered no intense heat about the heart when he inserted a finger into the wound. He then measured the degree of heat of the heart with a thermometer and using the same instrument he determined the temperature of the liver, the lungs, and the intestines, and concluded that

[9] Aristotle, *Parts of animals*, with an English translation by Peck, A. L., 652*b*, Cambridge, Mass., London (Loeb Classical Library), 1955.

[10] Galen, De utilitate respirationis, Ch. III, in C. G. Kuhn, *Claudii Galeni opera omnia* **4**: 491–493, Leipzig, 1825. See also Wilson, Leonard G., Erasistratus, Galen and the pneuma, *Bull. Hist. Med.* **33**: 293–314, 1959.

[11] As cited from Harvey's *Prelectiones anatomiae universalis* in Curtis, John G., *Harvey's views on the use of the circulation of the blood*, 19, New York, 1915.

[12] Harvey, William, *Anatomical studies on the motion of the heart and blood*, trans. and annotated by C. D. Leake, 59, Springfield, Ill., 1949.

[13] *Ibid.*, 105.

[14] For an excellent recent review of seventeenth century theories of respiration see Wilson, L. G., The transformation of ancient concepts of respiration in the seventeenth century, *Isis* **51**: 161–172, 1959.

[15] Mayow, John, On respiration, in *Medico-physical works: being a translation of tractatus quinque medico-physici* (1674), 206, Edinburgh, 1907.

[16] Mayow, John, On muscular motion and animal spirits, *ibid.*, 248–249.

the heart is no warmer than the other visceral organs.[17]

These few examples provide evidence of the shift, from the early views of Harvey (in many ways indistinguishable from those of Aristotle and Galen)[18] to the later belief that the heart is in no way different from any number of other organs. It should be noted that, as imposing as this combination of speculation and evidence looks in retrospect, it was not decisive for the contemporaries or immediate successors of these seventeenth-century physiologists.[19]

Stephen Hales, who was familiar with the work of Borelli and Mayow, was able to ignore the conclusions of both when he devised his own theory of animal heat. He believed that the blood acquired warmth owing to the brisk agitation that it underwent in its passage through the lungs. The lungs also cooled the blood by means of the respired air. Using a thermometer, Hales noted that the air is very rapidly heated in the lungs: for when air inspired through the nose was exhaled through the mouth it raised the mercury.[20]

Hales had operated on live animals often enough, however, to realize that the lungs were not abnormally hot.[21] The sensible heat which had been generated in the blood in the lungs was rapidly diminished, he concluded, as this blood was mixed with the mass of blood of the body. This combined with the cooling due to inspired air led to the paradox that Hales recognized: "as the Blood is most heated in the Lungs, by reason of the great Velocity and Friction it there undergoes, so it is there also most refrigerated."[22]

Other early eighteenth-century scientists, who believed that animal heat was generated by the friction or agitation of the blood as it passed through the fine capillaries, were unwilling to accept the paradox that Hales had recognized, and consequently shifted the major site of friction from the pulmonary to the systemic vessels. George Martine supposed that the different velocities of the blood as it moved through the extremities accounted for the almost uniform temperature he had measured throughout the body.[23] The ability of the capillaries to constrict and relax and thus vary the amount of friction encountered by the blood 'globules' in their passage, was believed by Robert Douglas to regulate the heat generation.[24]

It seems quite clear that by the middle of the eighteenth century the problem of animal heat was divided into two parts, one dealing with the mechanism of heat production and the other concerned with how and where this process occurred within the animal system. Moreover, new thermometric measurements had demonstrated that the body was not uniform in temperature and had a noticeable variation from the warmer internal organs to the cooler extremities.[25] Thus, the picture was somewhat confused. Although the problem of where in the body the heat was generated was recognized, the data did not demand any single solution. John Hunter, the very man who made the body temperature measurements, pointed to the warm visceral or "vital" organs and identified them as the site of some principle peculiar to life which had the power to preserve and regulate the internal machine.[26]

It is against this background of confusion in both theory and observation that the new proposal, likening animal heat to combustion, was made. Joseph Black recognized that air was similarly altered by both respiration and combustion and that the "warmer animals are, the more perfect, and constant is their respiration, and the more quickly do they infect the air with a malignant nature." From which he concluded that animal heat is caused by respiration and that

[17] Borelli, Giovanni, *De motu animalium* **2**: 137–138, 2nd ed., Lugduni Batavis, 1685.

[18] Harvey's own views on the subject were changing. See Harvey, William, *Anatomical exercises on the generation of animals*, in the *Works of William Harvey*, trans. Robert Willis, 502ff., London, 1847.

[19] Thomas Willis for example examined all the proposals and still concluded that the vital flame needed to be constantly fed. See *Dr. Willis's practice of physick, being the whole works of that renowned and famous physician*, 24, London, 1684.

[20] Hales, Stephen, *Statical essays: containing haemastaticks, or, an account of some hydraulick and hydrostatical experiments made on the blood and blood-vessels of animals* **2**: 98, London, 1733.

[21] *Ibid.*, 77. He described an incision made between the ribs into the thorax of a living dog.

[22] *Ibid.*, 104.

[23] Martine, George, Some thoughts concerning the production of animal heat, and the divarications of the vascular system, being an abstract from a latin treatise of the heat of animals: in a letter to Dr. John Stevenson physician in Edinburgh, *Medical essays and observations* **3**: 111–129, 5th ed., 1771.

[24] Douglas, Robert, *An essay concerning the generation of heat in animals*, London, 1747.

[25] See for example the measurements made by John Hunter, Of the heat, & c. of animals and vegetables, *Phil. Trans Roy. Soc.* **68**: 17–23, London, 1778.

[26] *Ibid., and Hunter*, Experiments on animals and vegetables with respect to the power of producing heat, *Phil. Trans. Roy. Soc.* **65**: 457 f., London, 1775.

the latter phenomenon is similar to combustion.[27] P. D. Leslie, a student of Black, claims that his teacher believed that the heat was generated in the lungs where air and the inflammable principle (phlogiston) combine in a manner similar to actual inflammation.[28]

The argument has come almost the full circle. It is not quite the "vital flame" in the heart which provided warmth to the blood; rather it is a simple combustion in the lungs which generates the animal heat. There is no record of whether Black recognized the difficulties his theory raised. His students, however, were quick to realize them, and his followers made efforts to avoid them.

Leslie himself adopted a view which cast doubt on the idea of the lungs as the source of heat. After all, had not Hunter demonstrated that a little heat was generated even by animals which had no respiratory organs?[29] Furthermore, Cullen and Stevenson claimed to have found venous blood to be warmer than arterial, a situation which would not be possible if the blood received its warmth in the lungs.[30] Another view attributed to Black, which was criticized by Leslie, suggested that the fetus was unable to generate heat of its own and consequently relied on maternal heat.[31] Leslie disagreed, and cited Stevenson's observation that late duck embryos produced their own heat for several hours after removal from the hen—the lungs not yet being active. This was interpreted by Leslie as overturning "Dr. Black's hypothesis, since it affords the clearest evidence of heat being generated in the animal machine before the lungs come into play."[32] Leslie's criticisms, while probably the earliest made of Black's theory of animal heat, were overlooked, for he failed to accept that part of Black's theory which was rapidly gaining acceptance—that respiration and combustion were similar processes.

It is the work of Adair Crawford which developed Black's theory of animal heat, and first dealt with the difficulties attendant upon having a combustion-like process take place in the lungs. Making use of the new theories of heat suggested by Black and Irvine, Crawford determined that atmospheric air had a greater capacity for heat than the fixed air which was a product of respiration and combustion.[33] He proposed that as atmospheric air was "fixed," or "phlogisticated," in the lungs its capacity for heat was reduced and it consequently gave up some of its heat. This in turn was taken up by the blood as it circulated through the lungs. Crawford was able to account for this addition of heat to the blood, an addition which occurred without rise in temperature, by demonstrating that the capacity for heat of arterial blood was greater than that of venous blood.[34] Arterial blood was thus able to contain a greater quantity of heat than venous blood and yet show no appreciable difference in temperature. During its circulation through the extremities the arterial blood had its capacity for heat reduced by the absorption of phlogiston, and the heat which it had taken up in the lungs was gradually given up and diffused through the whole system.[35] Although Crawford essentially has described the process of combustion as occurring in the lungs, he avoided the problem of overheating, or burning up the lungs through two devices. One was by treating heat as a substance which could be transferred from body to body in a non-sensible state. Secondly, by ascribing to the two bloods of the body different heat capacities, he provided an explanation whereby one blood (arterial) could contain substantially more "absolute" heat than the other (venous) without any temperature differential. Thus, the animal heat could be generated in (or more accurately enter the body through) the lungs without the lungs being any warmer than other internal organs.

John Elliott, writing at the same time as Crawford, developed a theory of animal heat closely resembling that of the latter author.[36] However, he did not include the idea of different heat capacities of the two types of blood and had, therefore, concluded that the blood was heated in the lungs by the fire released from air when it combined with phlogiston. Upon reading Crawford's treatise he realized that he "had fallen into an

[27] Reported by Rutherford, Daniel, *Dissertatio inauguralis de aere fixo dicto, aut mephitico*, Edinburgh, 1772, translated by Crum Brown and communicated by Leonard Dobbin as Daniel Rutherford's inaugural dissertation, *Jour. Chem. Educ.* **12**: 373–374, 1935.

[28] Leslie, P. Dugud, *A philosophical inquiry into the cause of animal heat: with incidental observations on several phisiological and chymical questions, connected with the subject*, 98–99, London, 1778.

[29] *Ibid.*, 77.

[30] *Ibid.*, 79.

[31] *Ibid.*, 82.

[32] *Ibid.*, 86–7.

[33] Crawford, Adair, *op. cit.*, 32, 1779.

[34] *Ibid.*, 58.

[35] *Ibid.*, 74.

[36] Elliott, John, *Philosophical observations on the senses of vision and hearing; to which are added, a treatise on harmonic sounds, and an essay on combustion and animal heat*, 184–215, London, 1780.

error in imagining that the blood is partly heated in the lungs."[37] He insisted, however, that some heat was generated in that organ. This was apparent from the single observation that air which was expired from the lungs was hotter than that which was inspired. He concluded that there was an evaporation of moisture from the lungs, regulated so that the heat of the blood was not increased as it passed through that organ.[38] This was not the solution that Crawford had relied upon, but like Crawford's proposal it made use of part of the new body of heat theory which was being developed at the time.

If Crawford had avoided a difficulty, Lavoisier was not as fortunate. He became slowly involved in the controversy over the site of animal-heat production (or combustion) and, judging from the subsequent literature on the subject, he never emerged with a successful solution. Lavoisier's contributions to the theories of combustion and respiration are too well known to repeat. Conceptually, his explanation of the source of animal heat is similar to that of Crawford and separated from it primarily by the gulf of terminology. The theory, developed first with the aid of Laplace and later with the assistance of Armand Séguin, proposed that heat was produced in the lungs by the alteration or decomposition of the "eminently respirable" portion of atmospheric air. In his earliest statements Lavoisier suggested that fire (or heat) was evolved in the lungs during the interval between inhalation and exhalation. This idea he based on two "certain and incontestable facts": one, that there was a decomposition of air in the lungs; and two, that all decompositions of pure air were accompanied by the evolution of the matter of fire.[39]

The famous "Mémoire sur la Chaleur," written in cooperation with Laplace, recognizes the problems raised by a "slow combustion" taking place in the interior of the lungs and not accompanied by the release of light.[40] No flame was visible, according to Lavoisier, because the fire was absorbed by the humidity of the lungs as soon as it was freed. He further suggested that the lungs are about the same temperature as other parts of the body because: the rapidly circulating blood quickly diffuses the heat; the heat effects evaporation in the lungs and thus lowers their temperature; and the specific heat of the blood is increased owing to its loss of the base of fixed air during contact with pure air in the lungs.[41] The last part of the three-point solution was probably adapted from Crawford, since Lavoisier provides no independent measurements of the specific heats of blood and does mention having read Crawford's book.[42]

In a paper published in 1785, Lavoisier talks of a carbonaceous substance which is extracted from the lungs during respiration.[43] The same work raises the possibility that part of the vital air which is not recovered in carbonic acid gas may combine in the lungs with a portion of the inflammable air to form water.[44]

The first of the Lavoisier–Séguin memoirs on respiration (1793) directly addresses the question of the site of formation of carbonic acid and concludes that there is no decisive evidence as to whether the combination occurs in the lungs or, alternately, during the circulation of the blood.[45] If the latter is the case, oxygen would have been absorbed by the blood in the lungs and then combined with carbon during the circulation. Or, possibly, the authors suggested, the carbonic acid was formed in digestion and entered the circulation with the chyle.[46]

It is in the later papers of Lavoisier and Séguin that the idea of a hydro-carbonous fluid became fully accepted. This humour was described as being continually separated from the blood and filtered through the membranes into the lungs where it combined with oxygen to form carbonic acid and water.[47] Obviously having in mind the question of how this combustion could occur in the lungs at body temperature, the authors compared the process to that which is observed in manure which "burns" at ordinary

[37] *Ibid.*, 214.

[38] *Ibid.*, 214–215.

[39] Lavoisier, Mémoire sur la combustion en général, *Mém. Acad. Roy. Sci.*, 599, 1777 (1780).

[40] Lavoisier and P. S. Laplace, Mémoire sur la chaleur, *Mém. Acad. Roy. Sci.*, 406, 1780 (1784).

[41] *Ibid.*, 406.

[42] *Ibid.*, 392, misspells the name Craford.

[43] Lavoisier, Mémoire sur les altérations qui arrivent à l'air dans plusieurs circonstances où se trouvent les hommes réunis en société, *Hist.* [*Mém.*] *de la Société Roy. de Médicine*, 573, 1782–1783 (1787).

[44] *Ibid.*, 574.

[45] Séguin, Armand, and A-L. Lavoisier, Premier mémoire sur la respiration des animaux, *Mém. Acad. Roy. Sci.*, 583, 1789 (1793).

[46] *Ibid.*, 583.

[47] Séguin and Lavoisier, Premier mémoire sur la transpiration des animaux, *Mém. Acad. Roy. Sci.*, 606, 1790 (1797); Second mémoire sur la transpiration des animaux, *Traité élémentaire de chimie* **2**: 234, 3rd edition, Paris, 1801; Second mémoire sur les respiration, *Ann. de chimie* **91**: 33, 1814.

atmospheric temperature.[48] Séguin had suggested earlier that, although a burning body was usually required to inflame hydrogen, and a heat equivalent to 150° Réaumur was necessary to ignite carbon, these combustions took place in the lungs without the presence of either of these agents.[49] This, he believed, was possible because the hydrogen was not disengaged and in gaseous form, and therefore it was not prevented by its attraction for caloric from combining with oxygen at ordinary temperatures; and the carbon could easily combust because it was held in a very divided state owing to its combination with hydrogen.[50]

What becomes clear is that the Lavoisier "explanation" of how combustion can take place in the lungs, and thus generate the animal heat, is not an explanation at all but is rather a series of somewhat connected conjectures and observations aimed at meeting specific problems. Right through the last papers of Lavoisier and Séguin the discussion of the site of combustion in the body remained provisional even though heavily favoring the lungs.

For Lavoisier's faithful adherents, however, no question remained. Pierre Adet in a response to Priestley's attack on the new chemistry pointed out that the carbonic acid produced in respiration was the result of a combination, made in the lungs, between carbon and oxygen. So that no doubts might linger, he noted that carbon in pure form was expectorated with mucus in several respiratory diseases. Adet added that during an illness he had suffered he found that his spittle was black and, searching for the cause, found that the color was due to carbon.[51] A similar explanation was proposed, by a Dr. Bree, for the dark color which is sometimes found in the mucus of the bronchial glands. The good doctor believed that asthmatic patients were not sufficiently able to carry off the carbon by formation of carbonic acid.[52]

With the general acceptance of the Lavoisier–Crawford theory of animal heat as a resultant of respiration, or slow combustion, much of the subsequent search for the site of body heat production revolved about two questions. What happens to the inspired oxygen? Or, alternately, where in the body was the carbonic acid *first* formed? A subsidiary and often perplexing question asked at what temperatures the products of combustion, carbonic acid and water, actually could be formed?

The last question is of particular interest because the heats of combustion of carbon and hydrogen were utilized in the early nineteenth-century attempts to establish the respiration theory of animal heat.[53] Séguin, citing Priestley and Bertholet, had argued that these combustions could occur at ordinary body temperature. Hugh Moises, in his *Treatise on the Blood* (1794), was equally emphatic:

> We know of no experiment which might authorize us to suppose that carbon can unite with oxygene in a temperature of 97°–99°, or that hydrogene and oxygene air combine and form water in so low a temperature.[54]

Questions of this sort are not easily answered. Daniel Ellis recognized the type of objection that Moises made and replied that throughout nature processes may be observed which produce carbonic acid at low temperatures. This acid he found produced by both the living functions of animals and plants as well as by the decomposition of animal and vegetable matter.[55] This led Ellis to infer that the carbonic acid, whether produced in the lungs or in the blood, did not arise from a process analogous to combustion.[56] Doubts of this sort were not uncommon among the physiologists of the early nineteenth century.

One group of physiologists solved the problem by turning away from the respiration theory of animal heat. They took their lead from Benjamin Brodie who had carried out a series of experiments on animals whose brains he had damaged. He had found that, although these animals continued to respire, circulate blood in a normal manner, and produce the same quantity of carbo ic

[48] Séguin and Lavoisier, Premier mémoire sur la transpiration animaux, *loc. cit.*, 606.

[49] Séguin, Observations générales sur las respiration et sur la chaleur animale, *Obs. Phys.* **37**: 469, 1790.

[50] *Ibid.*, 469.

[51] Adet, P. A., *Reponse aux réflexions sur la doctrine du phlogistique et de la décomposition de l'eau*, 77, Philadelphie, 1797.

[52] Cited in Bostock, John, *An essay on respiration*, 127, Parts I and II, Liverpool, London, 1804.

[53] See for example Despretz, C., Recherches expérimentales sur les causes de la chaleur animale, *Ann. Chim. Phys.* **1**: 440–455, 3rd ser., 1841.

[54] Moises, Hugh, *A treatise on the blood, or, general arrangement of many important facts, relative to the vital fluid, with some cursory observations on the theory of animal heat. Interspersed with pathological and physiological remarks from the inductions of modern chemistry*, 192, London, n.d. [1794].

[55] Ellis, Daniel, *An inquiry into the changes induced on atmospheric air, by the germination of seeds, the vegetation of plants, and the respiration of animals*, 124, Edinburgh, 1807.

[56] *Ibid.*, 124.

acid as was usual, they generated no heat and actually cooled more rapidly than dead animals.[57] He proposed that the brain and nervous system were intimately connected with the production of the body's heat. Objecting to the theories of Black, Lavoisier, and Crawford, Brodie offered the challenge:

> Where so many and such various chemical processes are going on, as in the living body, are we justified in selecting any one of these for the purpose of explaining the production of heat?[58]

With the exception of a number of followers,[59] who joined Brodie in research on the role of the nerves in heat production, the answer to his question was a resounding yes.

It is interesting to notice, in retrospect, the direction that investigations took in the years following Lavoisier's and Crawford's postulation of their new theory. Hindsight tells us the important place to look was in the tissues. Most workers, however, limited themselves to one tissue only, the blood. Some few recognized that the respiratory products were found in portions of the body other than the lungs. Cruikshank, Abernethy, and Ingenhousz all recorded finding fixed air or carbonic acid gas emitted from the skin.[60] Even though Cruikshank showed familiarity with Crawford's theory he nowhere suggested that heat production might occur on the surface of the body.[61] In their second memoir on transpiration Lavoisier and Séguin recognized that animals did not respire in the lungs alone, but also on the whole body surface.[62] A hydrocarbonous, viscous humour like that supposed for the bronchials was believed to seep through the pores of the skin. Carbonic acid and water were identified as emanating from the cutaneous surface.[63] Although obviously implicit, the authors do not make explicit the role of cutaneous respiration in body heat production.

These early works on non-pulmonary respiration were supplemented by the extensive research of the Abbé Lazzaro Spallanzani. Through a series of simple, decisive experiments he was able to conclude that many parts of the animal body, such as the muscle, tendons, bones, brain, fat, and blood, in effect, respire.[64] And blood did not seem to do so in any greater degree than other tissues. There was no direct implication of the importance of this conclusion to the theory of animal heat. With few exceptions these early studies of tissue respiration were overlooked by those working on the problem of animal heat. It was only after the development of the thermo-electric temperature-measuring device by Becquerel and Breschet,[65] and its use in the important studies of Helmholtz,[66] that the full implications of tissue respiration were realized. In the meantime the lungs and the blood were the center of study and controversy.

One of the earliest critics of the Lavoisier–Crawford theory of animal heat was Christoph Girtanner, the man who had brought the Lavoisier chemical doctrines to Germany. Girtanner, writing in 1790, objected to the idea of carbon uniting with the oxygen of the lungs at 30° centigrade.[67] Nor was he impressed by Séguin's attempts to answer the objections by supposing that the carbon was in a very divided state when secreted from the blood. Instead Girtanner suggested that part of the oxygen was absorbed by the blood itself and in so doing increased the blood's capacity for heat. During the circulation, he proposed, the blood loses its oxygen (oxygen and caloric) and takes up a "carbonated hydrogen" gas through a double affinity. During this distribution of oxygen the caloric with which it is united is released in the system thus providing the animal heat.[68] Although Girtanner was anx-

[57] Brodie, B. C., Further experiments and observations on the influence of the brain on the generation of animal heat, *Phil. Trans. Roy. Soc.* **102**: 388, London, 1812.

[58] *Ibid.*, 391.

[59] The early work on the role of the nerves is really a separate problem. Contributions were made by Enoch Hale, Auguste Cornilleau, Julien J. C. Legallois, and others.

[60] Cruikshank, William, *Experiments on the insensible perspiration of the human body, showing its affinity to respiration*, published originally in 1779, and now republished with additions and corrections, "Advertisement" and 61, London, 1795.

[61] *Ibid.*, 91.

[62] Lavoisier and Séguin, Second mémoire sur la transpiration des animaux, *loc. cit.*, 237.

[63] *Ibid.*, 236.

[64] Spallanzani, L., *Memoirs on respiration*, edited from the unpublished manuscripts of the author by John Senebier, 91, London, 1804.

[65] Becquerel, A. C., and G. Breschet, Recherches sur la chaleur animale, au moyen des appareils thermo-électriques, Paris, *Mus. Nat. Hist. Archives* **1**: 383–404, 1839, and other papers.

[66] Helmholtz, Herman, Ueber die wärmeentwickelung bei der muskelaction [1847], *Wissenschaftliche abhandlungen* **2**: 745–763, Leipzig, 1883.

[67] Girtanner, Christoph, Mémoire sur l'irritabilité, considérée comme principe de vie dans la nature organisée, second mémoire, *Obs. Phys.* **37**: 140, 1790.

[68] *Ibid.*, 148.

ious to prove that the arterial blood contained oxygen, he hesitated suggesting that all the inspired oxygen was absorbed by the blood. Instead he accepted one of the possibilities upon which Lavoisier had speculated, the absorption of a part of the oxygen. The remainder he concluded, combined in the lungs with carbon and hydrogen.[69] Girtanner's theory strongly resembles Crawford's in choice of the site of heat release and differs from it only in the means by which the heat is carried into the body.

Recognizing the inadequacy of Girtanner's solution, J. L. Lagrange (the mathematician) proposed that the blood in passing through the lungs absorbed all the respired oxygen.[70] During the circulation the oxygen was slowly freed from the dissolved state and combined with the carbon and hydrogen of the blood to form the carbonic acid and water which were later discharged from the venous blood into the lungs. The animal heat was generated in this combination. By means of this hypothesis, Lagrange believed one could easily explain why there was little or no difference between the temperature of the lungs and that of other internal organs. He also believed that he had explained how the caloric could reach the extremities.[71] The questions which Lagrange's hypothesis raised were those to which several generations of physiologists devoted their efforts. They attempted to determine experimentally whether there was oxygen in the arterial blood and carbonic acid in the venous blood. The controversy over the site of heat production in the body had been narrowed down to a question of the presence or absence of gases in the blood.

The early studies of this limited problem suggested solutions based on the ability of the different gases to cause the color changes observed in blood. Both Girtanner and Hassenfratz had attempted to show that venous blood became bright red upon the absorption of oxygen, and thereby demonstrated their contention that the blood took up oxygen in the lungs. Another line of experimentation attempted to recover gases from the blood. Hugh Moises, for instance, confined arterial blood in bottles with gases containing no oxygen, and claimed to find oxygen in the residue.[72]

In his earliest published paper Humphry Davy proposed some changes in the currently accepted theories of respiration and animal heat.[73]

> Respiration is a chemical process, the combination of phos-oxygen [oxygen and light] with the venous blood in the lungs, and the liberation of carbonic acid and aqueous gas from it.[74]

The animal heat arose from an increase of repulsive motion caused by the chemical combination and decompositions taking place in the system. In order to show that the "phos-oxygen" was actually absorbed by the venous blood, he enclosed the blood and gas in a phial. After half an hour he found that some of the gas had been absorbed. Having carried out the experiment in the dark and observing that no light was liberated, Davy was able to conclude that the "phos-oxygen" (oxygen and light) had not decomposed but had instead combined with the venous blood.[75] In another experiment Davy heated arterial blood to 108° F. and collected the liberated gas. Upon analysis he found carbonic acid and "phos-oxygen," which proved to him that "phos-oxygen" had been absorbed by the arterial blood.[76]

A number of other experiments, probably inspired by the work on gas absorption of William Henry and John Dalton, attempted to show that the blood did take up the respiratory gases. Allen and Pepys made use of a gasometer to demonstrate an exchange in the blood between azote (nitrogen) and oxygen.[77] Everard Home reported the separation of carbonic acid from venous blood confined in a receiver from which the air had been withdrawn.[78]

Although the piling up of evidence in favor of the Lagrange hypothesis should have given it great weight, the proposal probably had as many doubters as supporters during the first two decades of the nineteenth century. A theory as well entrenched, and as prominently supported as the

[69] *Ibid.*, 141.

[70] As reported by Hassenfratz, Jean, Mémoire sur la combinasion de l'oxigène avec le carbone et l'hydrogène du sang, sur la dissolution de l'oxigène dans le sang, et sur la manière dont de calorique se dégage, *Ann. Chim.* **9**: 266, 1791.

[71] *Ibid.*, 267.

[72] Moises, *op. cit.*, 208.

[73] Davy, Humphry, Essay on heat, light, and the combinations of light, with a new theory of respiration [1799]. *Collected works* **2**: 1–86, London, 1839.

[74] *Ibid.*, 79.

[75] *Ibid.*, 76–78.

[76] *Ibid.*, 78.

[77] Allen, William and William H. Pepys, On respiration, *Phil. Trans. Roy. Soc.* **99**: 404–428, London, 1809.

[78] Home, Everard, The Croonian lecture. On the changes the blood undergoes in the act of coagulation, *Phil. Trans. Roy. Soc.* **108**: 181, London, 1818.

Lavoisier–Crawford theory of animal heat did not give way easily. While recognizing that gases when in contact with some fluids could become diffused through the fluids, Daniel Ellis rejected the opinion that this was true in the case of oxygen and blood.[79] Ellis believed that the attraction of oxygen by the blood through the coats of the vessels was inconsistent with the laws of chemical attraction and affinity. He denied that there existed any proof which showed air to be present in healthy blood.[80] In an extensive review of research developments in respiration and animal heat John Dalton claimed that there were as yet no decisive experiments on the question of whether oxygen combines with the blood and produces carbonic acid in the process of circulation.[81] He rightly pointed out that many of the results could be interpreted so as to be in accord with the Lavoisier–Crawford theory. Dalton was definitely inclined to accept the main principles of Crawford's theory: ". . . indeed his results . . . are so plausible, and his whole theory so beautiful, that one would feel a regret in having to question the accuracy of his principles."[82]

During the 1830's a high point was reached in the efforts to resolve the question of whether the carbonic acid was produced in the lungs or the blood. The old experiments were repeated. Better pneumatic apparatus was utilized. Contradictory results were harmonized. These efforts reached their culmination in the carefully executed researches of Gustav Magnus.[83] He was able to recover carbonic acid from venous blood by several methods. He subjected the blood to atmospheres of other gases and also to very low pressure achieved with a vacuum pump. He then argued that if the carbonic acid was already formed in the venous blood, its release from the blood (into the lungs) should follow the same laws that govern the release of any gas dissolved in a liquid. An equal volume of a new gas should be absorbed by the liquid.[84] Magnus found confirmation for his view when he demonstrated that arterial blood contained oxygen.[85] He recognized, however, that according to the laws of absorption not all the carbonic acid would be released in the lungs and that some must be contained in the arterial blood. The results that he ultimately achieved showed that all blood contained oxygen, carbonic acid, and nitrogen. He found that the arterial blood was richer in oxygen than the venous blood, and that the venous blood had higher proportion of carbonic acid than the arterial blood.[86] It became apparent to Magnus that the carbonic acid could not be produced in the lungs, but rather was generated in the blood during circulation. He suggested that as the oxygenated blood passed through the capillaries an oxidation occurred, producing carbonic acid.[87]

Magnus' work, which received rapid confirmatoin,[88] answered only the limited question: was carbonic acid formed in the lungs or in the blood? But since it was widely assumed that the animal heat was due, in large measure, to this combination, the site of body heat production was shifted from the lungs to the capillary beds. Only when Magnus' results were taken together with the new researches demonstrating that respiration actually occurred in the tissues, and only in small part in the blood, did it become clear that the respiratory process was not a simple combustion, a simple combination of carbon with oxygen.

Animal heat was produced within the animal tissue. Early indications of this fact had been given in the direct measurements of Becquerel and Breschet. Clear demonstration was provided by Helmholtz when he measured the amount of heat generated by the twitch of isolated muscle. But it was not until the twentieth century that we have come to understand the nature of "organic combustions." The discovery that energy is released through enzymatic activation of oxygen provided the explanation of the flameless fire that burned within the living body.

[79] Ellis, Daniel, *op. cit.*, 124.

[80] *Ibid.*, 142.

[81] Dalton, John, On respiration and animal heat, *Mem. Manchester Lit. Phil. Soc.* **2**: 36, 2nd ser., 1813.

[82] *Ibid.*, 38–39.

[83] Magnus, Gustav, Ueber die im blute enthaltenen gase, sauerstoff, stickstoff und kohlensäure, *Annal. Phys. Chem.* **40**: 583–606, 1837.

[84] *Ibid.*, 589.

[85] *Ibid.*, 590.

[86] *Ibid.*, 600–601.

[87] *Ibid.*, 602.

[88] See Davy, John, An account of some experiments on the blood in connexion with the theory of respiration, *Phil. Trans. Roy. Soc.*, 283–299, London, 1838.

SYSTEMATIC AND ECOLOGICAL RELATIONS OF *PEROMYSCUS OREAS* AND *P. MANICULATUS*

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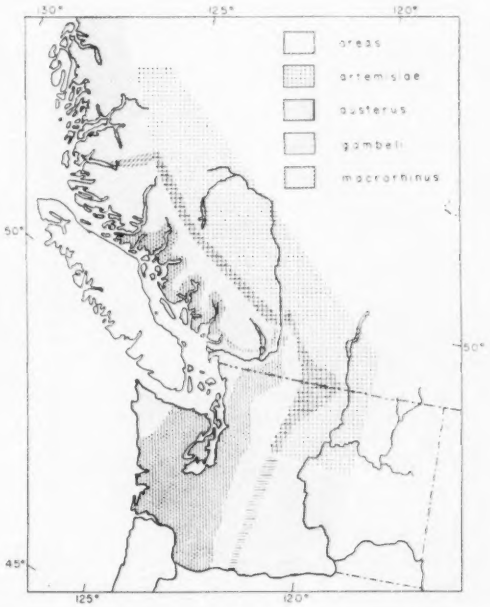
INTRODUCTION

THE deer mouse *Peromyscus maniculatus* (Wagner) is one of the most widely distributed mammals in North America, and within its great range it occupies a variety of habitats and exhibits a corresponding variety of geographic variation. The current systematic concept of this species is essentially that of Osgood (1909). He placed in *maniculatus* a number of races previously considered distinct species, basing this action on their apparent intergradation with *maniculatus*. One of the species reduced to subspecific status was *Peromyscus oreas* Bangs. Osgood reported that *oreas* intergrades with three of the four subspecies of *P. maniculatus* with which it comes in contact, but he presented no evidence for such intergradation. Later workers usually have agreed that *oreas* intergrades with *maniculatus*, but also have failed to provide supporting evidence. On the other hand, a number of workers have reported taking both *oreas* and the race *P. m. austerus* at some localities without finding evidence of intergradation, although these races are said to intergrade in other areas. The purpose of the present study was to clarify the biological relations between *oreas* and the races with which it comes in contact. The results show that *oreas* is substantially reproductively isolated from *maniculatus* and therefore deserves full specific status.

Peromyscus oreas occurs from the eastern foot of the Cascade Mountains and British Columbia Coast Range to the Pacific Ocean, from the lower Columbia River north to Rivers Inlet, B. C. (map 1). Adjacent and overlapping races of *P. maniculatus* are: (1) *P. m. austerus* (Baird), which occurs throughout much of western Washington and on the southern British Columbia coast west of the Coast Range summit; (2) *P. m. macrorhinus* (Rhoads), which occupies the northern British Columbia coast and extends northward into Alaska; (3) *P. m. artemisiae* (Rhoads), which occupies a large area east of the Cascades-Coast Range from central Washington north to central British Columbia and east to Montana; (4) *P. m. gambeli* (Baird), which occurs east of the Cascades in southern Washington and south through Oregon and California. Each of these races of *maniculatus* (except perhaps *artemisiae* vs. *gambeli*) differs from the others by a number of good characters, these characters vary more-or-less concordantly, and the differences between the races are much greater than between populations of one race.

This work has been made possible by the generous help of many persons and institutions. It was carried out primarily at the University of British Columbia, but a year was spent at the Museum



MAP 1. Distribution of *Peromyscus oreas* and four races of *P. maniculatus* in western Washington and British Columbia. Insular distribution is not shown.

of Vertebrate Zoology of the University of California. Individuals who helped in various ways include Dr. I. McT. Cowan, Dr. Donald Smith, and Mr. and Mrs. Pat Wright. The directors of the United States National Museum, the National Museum of Canada, and the British Columbia Provincial Museum lent many valuable specimens from their collections. The field work was supported in part by the University of British Columbia Research Committee, the National Research Council of Canada, and the American Philosophical Society.

PROCEDURE

Extensive collecting was done in British Columbia and Washington to determine more precisely the geographic distribution of the races of *Peromyscus* living in this region and to search for evidence of intergradation. Thirty-eight weeks were spent in the field during the summers of 1955-1959. Most of this time was devoted primarily to collecting *Peromyscus*. Because the most valuable criteria for distinguishing between the races in question are those of dimensions rather than pelage, effort was concentrated on making external measurements and collecting skulls of large numbers of individuals, while relatively few study skins were made. A total of 1244 *Peromyscus* were collected during the course of this study. In addition, the collections of several museums were examined, as well as specimens in a few private collections. Altogether, approximately 2800 specimens were examined.

The primary purpose of the study was to determine the nature of the relations between neighboring races, i.e. to determine whether they intergrade, hybridize, or do not interbreed at all. Because of this, the main method of analysis has been to attempt the positive identification of each specimen. Statistical analysis of whole samples has been used as a supplement to individual identification. Some attention has also been paid to geographic variation within each race.

A laboratory colony of *P. orcas*, *P. m. austerus*, and *P. m. artemisiae* was kept for ten months to determine the ability of these races to interbreed. During the field work special attention was paid to the habitats in which the mice were found. The habitat distribution of these races is described, and the possible reasons for this distribution are considered. The evolutionary history of these races is discussed in the light of their systematic status and distribution and the geologic history of the region. Field and laboratory data of life history are examined for interspecific differences in reproduction and behavior.

SYSTEMATIC RELATIONS

I. VARIATION IN *PEROMYSCUS*

The most useful systematic characters in these races are the standard measurements of external dimensions—total length, tail length, and hind foot length. Each of these dimensions is subject to significant errors of measurement, making it difficult to interpret data falling outside the expected range of variation.

Sources of variation within a population include sex, age, and individual variation. Sex variation is easily eliminated. Age variation was reduced either by bivariate analysis or by sorting the samples into age groups. Individual variation was controlled by statistical analysis of the entire catch from each collecting station.

Specimens were divided into five age groups on the basis of tooth wear (Sheppe, in press). Group 1 represents the early juvenal stage, approximately twenty-five to thirty days of age. Mice enter group 2 at about one month of age and remain in this group throughout the first summer. Group 3 mice collected during the summer were born the previous year. Groups 4 and 5 cannot readily be interpreted in terms of absolute age, but group 5 mice must be at least two years old. Unless otherwise stated, "young" refers to group 2 only, while "adult" refers to groups 3, 4, and 5.

Analysis of taxonomic characters was based on the largest samples of positively identified animals. The localities at which these samples were collected are listed in Sheppe, 1958.

a. Body Length

Body length is calculated by subtracting tail length from total length. Pooled body length data for the above samples of *orcas* are analyzed for sex and age variation in figure 1. Results for the other races are similar. This figure is drawn in the manner suggested by Hubbs and Hubbs (1953). The horizontal line represents the range of variation in the sample and the vertical line represents the mean. The hollow rectangles represent one standard deviation on either side of the mean, while the solid rectangles represent two standard errors of the mean on either side of the mean. Standard deviation and standard error were not calculated for samples of less than

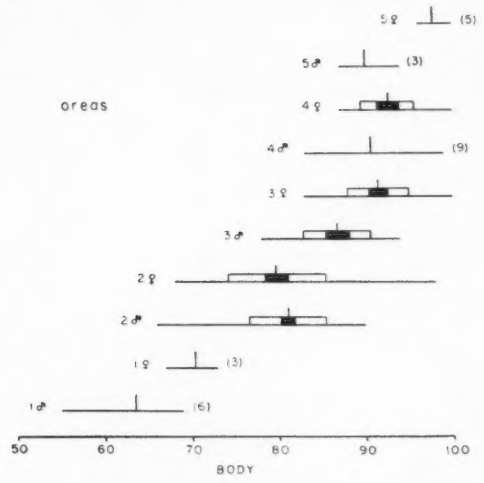


FIG. 1. Age and sex variation in body length of *Peromyscus oreas*. Dimensions in all graphs are in millimeters.

ten specimens; the number of specimens in such samples is indicated in parentheses on the right.

There is much overlap of range of variation between age classes, no class being distinct from all others. Age group 1 averages much smaller than group 2 and group 2 averages significantly smaller than group 3 in those races for which adequate samples were analyzed. Differences between groups 3, 4, and 5 are slight and inconsistent, but the older groups tend to be larger.

There is little sexual dimorphism in *Peromyscus*. Males of group 2 average slightly larger than females of group 2 in each race, but adult females average larger than males. Apparently young males are slightly larger than young females, but thereafter the females grow at a faster rate and average somewhat larger than males by the time they are one year old.

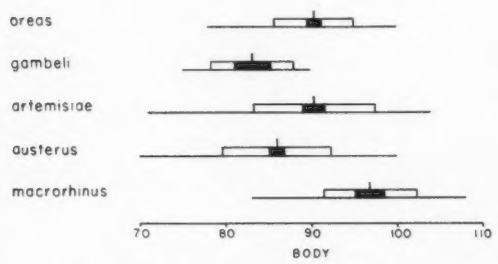


FIG. 2. Body length of five races of *Peromyscus*.

Figure 2 shows the body length for adults of both sexes of each of the five races. All the races overlap a great deal, but there are slight average differences. *Macrorhinus* is the largest race, averaging 96.86 mm. long. *Orcas* and *artemisiae* are of almost the same size (90.45 mm. and 90.36 mm.). *Austerus* is distinctly smaller than either (86.04 mm.) and *gambeli* is the smallest of all (83.24 mm.). These differences correspond well to those observed by Osgood (1909) and others. Because of the amount of overlap between races body length is of little value in identifying individual specimens, but it is sometimes of supplementary value in characterizing samples.

Orcas is remarkably uniform in body length throughout its range, seven samples showing mean differences not exceeding 5 mm. There are no apparent geographical trends. The two samples with largest means are the most northern and the most southern. Samples from the Olympic Peninsula, the western side of the Cascades, and the eastern side of the Cascades are almost identical.

Three samples of *austerus* from the Puget Sound-Fraser Delta area are no more different from each other than could be expected from differences in sample composition and measurement techniques. A sample composed of mice from three localities north of Burrard Inlet, B. C., is much larger than more southern samples. Three samples of *artemisiae* from southern British Columbia are similar, but one from Anahim Lake, much farther north, is much larger.

b. Tail Length

As with body length, the greatest age differences are between groups 1 and 2 and groups 2 and 3, though growth seems to continue slowly throughout life. In four of the five races studied group 2 males have longer tails than do females, but adult females usually have slightly longer tails than adult males.

This character has proved to be the most useful one for distinguishing between *orcas* and most of the races of *maniculatus*. Figure 3 shows that the range of variation of *orcas* does not overlap that of *artemisiae* and *gambeli*, and overlaps that of *austerus* only slightly. *Orcas* and *macrorhinus* are similar in this dimension, averaging 112.92 mm. and 110.22 mm. respectively. In these two races the tail is always longer than the body. In *artemisiae* (79.89 mm.) and *gambeli* (78.38 mm.) it is almost always shorter than the body, and in

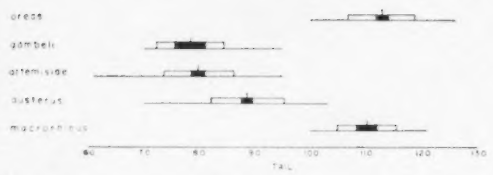


FIG. 3. Tail length of five races of *Peromyscus*.

austerus (88.72 mm.) it may be either longer or shorter.

Different samples of *oreas* show little difference in mean tail length, ranging from 109.93 mm. to 116.00 mm. There are significant unexplained differences among samples of some of the races of *maniculatus*.

c. Bivariate Analysis—Tail Length/Body Length

It was found that scatter diagrams of tail length against body length provide a more satisfactory means of analysis than either dimension considered alone. The entire sample can be considered simultaneously rather than broken into age groups, and differences which previously were obscure often become clear-cut. The points for each race tend to be grouped together, separate from those for other races. These groupings, if the points are normally distributed, may be conveniently described by the equal-frequency ellipse method of Defrise-Gussenhoven (1955). These ellipses are calculated to include approximately 95 per cent of the points composing the sample. Samples may be more readily compared by means of their ellipses than by the original scatter of points. In calculating ellipses I have used a method shown me by Mr. Pierre Jolicoeur (Appendix 1).

The ellipse is characterized by midpoint, length of major and minor axes, and slope of major axis ("*m*"). The midpoint is determined by the means of the two dimensions. Its value is greater for samples composed largely of adults than for those containing many young animals. The length of the major axis reflects the age composition of the sample; the length of the minor axis reflects the degree of correlation between the two dimensions. If the correlation is perfect all points will fall in a line and the minor axis will equal zero, while if there is no correlation the points will form a circle and the minor axis will equal the major axis. The slope of the major axis shows the mathematical relation between the two dimensions.

In the analysis of populations (Section II) scatter diagrams of tail/body data for some of the large samples are shown fitted with equal-frequency ellipses. Figure 4 shows the outline of the combined ellipses for each race. *Artemisiae* and *gambeli* have similar positions on the graph, *oreas* is above them, and *austerus* is intermediate, as would be expected from the univariate analysis above. *Macrorhinus* is on a level with the adult *oreas* samples, but to their right, reflecting the greater body length of that race. Differences in slope are apparent for some of the ellipses.

The relative rates of growth of different parts of the body have been shown to be of systematic value by Huxley (1932) and others. The relative growth constant ("*a*") is the mathematical expression of the relation between the growth rates of two parts. The most satisfactory formula for calculating relative growth constants is the standard major axis of Tessier and Haldane (Imbrie, 1956). Its slope is the ratio of the standard deviations of the two variables (S_y/S_x). In the present work calculations were based on the original data rather than their logarithms because the observed growth was nearly straight-line.

Growth constants (tail length/body length) for several samples of *Peromyscus oreas* and *P. maniculatus* are listed in table 1. The values for all samples of *oreas* are higher than those for *maniculatus*. All samples of *maniculatus* have growth constants less than 1.15; all samples of *oreas* have growth constants greater than 1.25. Some of these values are not very reliable, but the consistency of the difference between *oreas* and *maniculatus* suggests that the difference is a real one. There are no consistent differences in the growth constants of the races of *maniculatus*, in spite of all the variety of size and proportion which they exhibit.

TABLE 1

GROWTH CONSTANTS OF TAIL LENGTH ON BODY LENGTH FOR SAMPLES OF *Peromyscus*

Race	Locality	*a*
oreas	Wright's	1.466
	Denny	1.357
	Neah Bay	1.273
gambeli	River Bend	1.142
artemisiae	Wright's	1.089
	Okanagan	0.882
	Anahim	0.970
austerus	Vancouver	1.118
	Cultus	1.023
macrorhinus	Central Coast	1.013

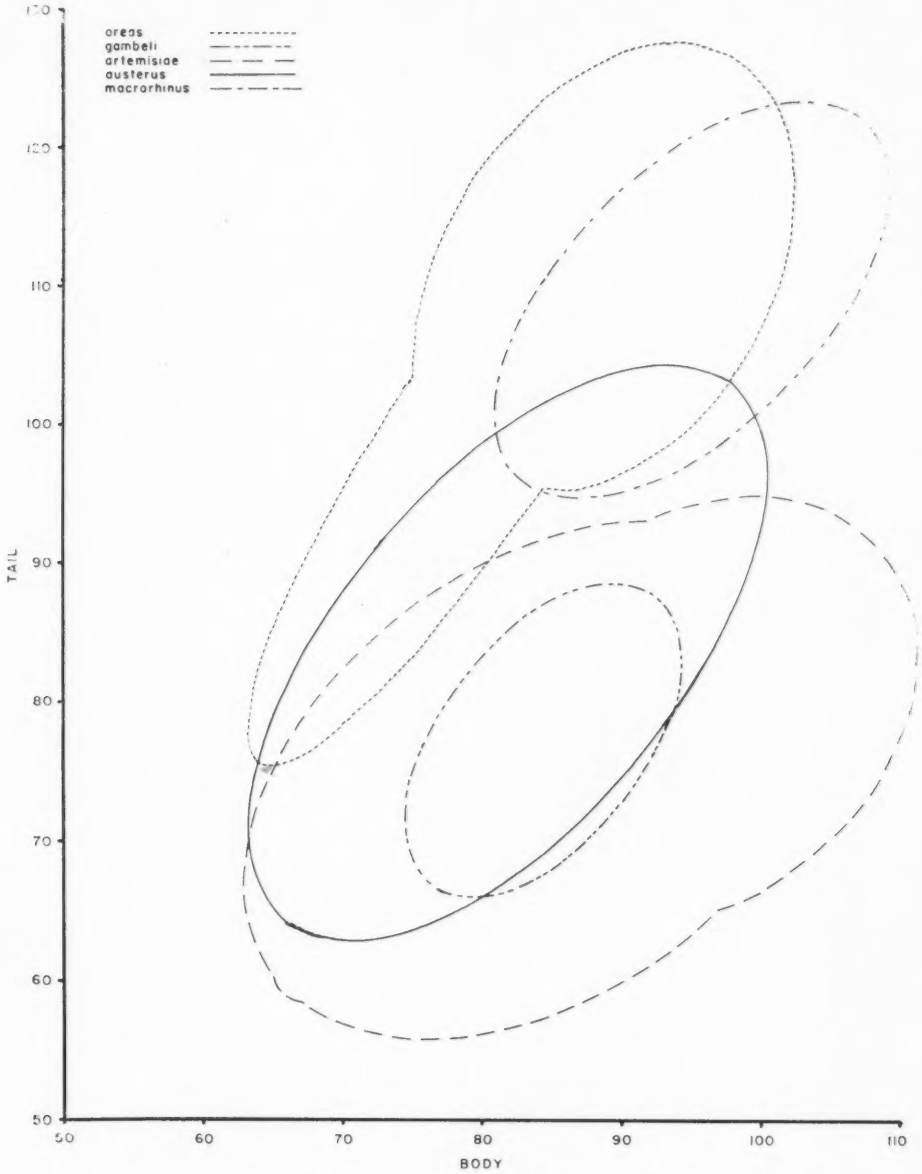


FIG. 4. Composite equal-frequency ellipses (tail length/body length) for five races of *Peromyscus*.

d. Hind Foot Length

The hind foot has attained almost full adult size in group 2 animals, and there is little or no growth in the older groups. Males consistently average longer hind feet.

Hind foot lengths for adults of each race are shown in figure 5. The range and means of hind foot length of *oreas* and *macrorhinus* are almost identical, while the other races have means $2\frac{1}{2}$–3 mm. lower. In my collection almost all

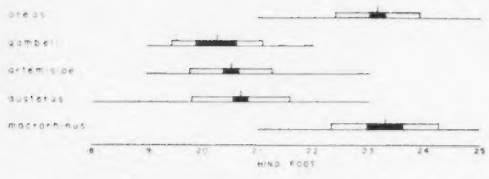


FIG. 5. Hind foot length of five races of *Peromyscus*.

orcas have hind feet more than 22 mm. long and almost all *austerus*, *artemisiae*, and *gambeli* have hind feet shorter than this. This dimension is one of the most valuable characters for separating *orcas* from *maniculatus* (except *macrorhinus*).

In seven samples of *orcas* mean hind foot length covers a range of about 1 mm., but there are no apparent geographic trends. There is some variation within the races of *maniculatus*.

e. Pelage Characters

Pelage characters are of value in distinguishing between most of these races, but geographic, age, and individual variation within each race is so great that it was rarely possible to make critical determinations on this basis.

f. Skull characters

It often is possible to identify by inspection most of the skulls in a series of *orcas* and one of the races of *maniculatus*, but the differences are not sufficiently clear-cut to be used with material of questionable identity. *Orcas* skulls reach a greater length than those of *artemisiae* and *austerus* (maximum 27.7 mm. vs. 26.6 mm. and 27.0 mm.), but tend to have relatively shorter nasals. *Gambeli* skulls are similar in length to those of *artemisiae*, but are intermediate between *artemisiae* and *orcas* in relative length of nasal. *Macrorhinus* skulls average longer than those of *orcas* (maximum 29.0 mm.), but the nasal is of the same relative length as in that race.

In summary, *orcas* is best distinguished from *gambeli*, *artemisiae*, and *austerus* by tail length (103 mm. or greater in *orcas*, 95 mm. or less in *gambeli* and *artemisiae*, 103 mm. or less in *austerus*) and hind foot length (usually 23 mm. or more in *orcas*, usually 21 mm. or less in *gambeli*, *artemisiae*, and *austerus*). Individual *orcas* cannot be readily distinguished from *macrorhinus*, but *orcas* tends to have a shorter body (78–100 mm., averaging 90.45 mm. in *orcas*; 83–108 mm., averaging 96.86 mm. in *macrorhinus*). All tail/body growth constants that have been calculated for *orcas* have been greater than 1.25, while all for *maniculatus* have been less than 1.15.

II. ANALYSIS OF POPULATIONS

The purpose of this part of the study was to clarify the geographic distribution of each race and to seek evidence of intergradation or hybridization between the races. An intergrade population is one which is geographically and morphologically intermediate between two neighboring races, and which shows no greater variability than do populations of those races. A hybrid population, on the other hand, contains both parent stocks and intermediates, and shows greatly increased variability. Both intergradation and hybridization involve gene exchange between two races. An apparent intermediate condition can also be caused by human error, environmental conditions, or genetic anomaly, requiring that caution be used in interpreting intermediate specimens in terms of gene exchange between populations. The following samples are discussed more fully in Sheppe, 1958.

1. *orcas* and *gambeli*

These races meet at the eastern edge of the Cascades in southern Washington. Osgood (1909) does not mention direct intergradation between them, but says they intergrade through *artemisiae*. Dalquest (1948: 91) says that "The pale, short-tailed desert mice (*gambelii*) gradually change to the dark, long-tailed subspecies, *orcas*, that occupies the Cascade Mountains." He lists no localities with intermediate populations. Johnson and Ostenson (1959), however, found no intergradation between these races. Fox (1948) states that these races apparently interbreed, but not freely. The situation is complicated by the fact that *gambeli* of the interior and *austerus* of the coast probably intergrade along the Columbia River, introducing the long-tail, dark-color genes of *austerus* into the region east of the mountains.

The higher parts of the Cascade Range in southern Washington are occupied only by *orcas*, while *gambeli* is the only race found on the Columbia River Plateau to the east. Both races are found in a rather narrow zone at lower elevations in the Cascades. No intergrade population was found, but a number of specimens that could not be positively identified were taken at localities where both *orcas* and *gambeli* were found, and some of these mice may have been hybrids.

A collection from Clear Lake, in Yakima

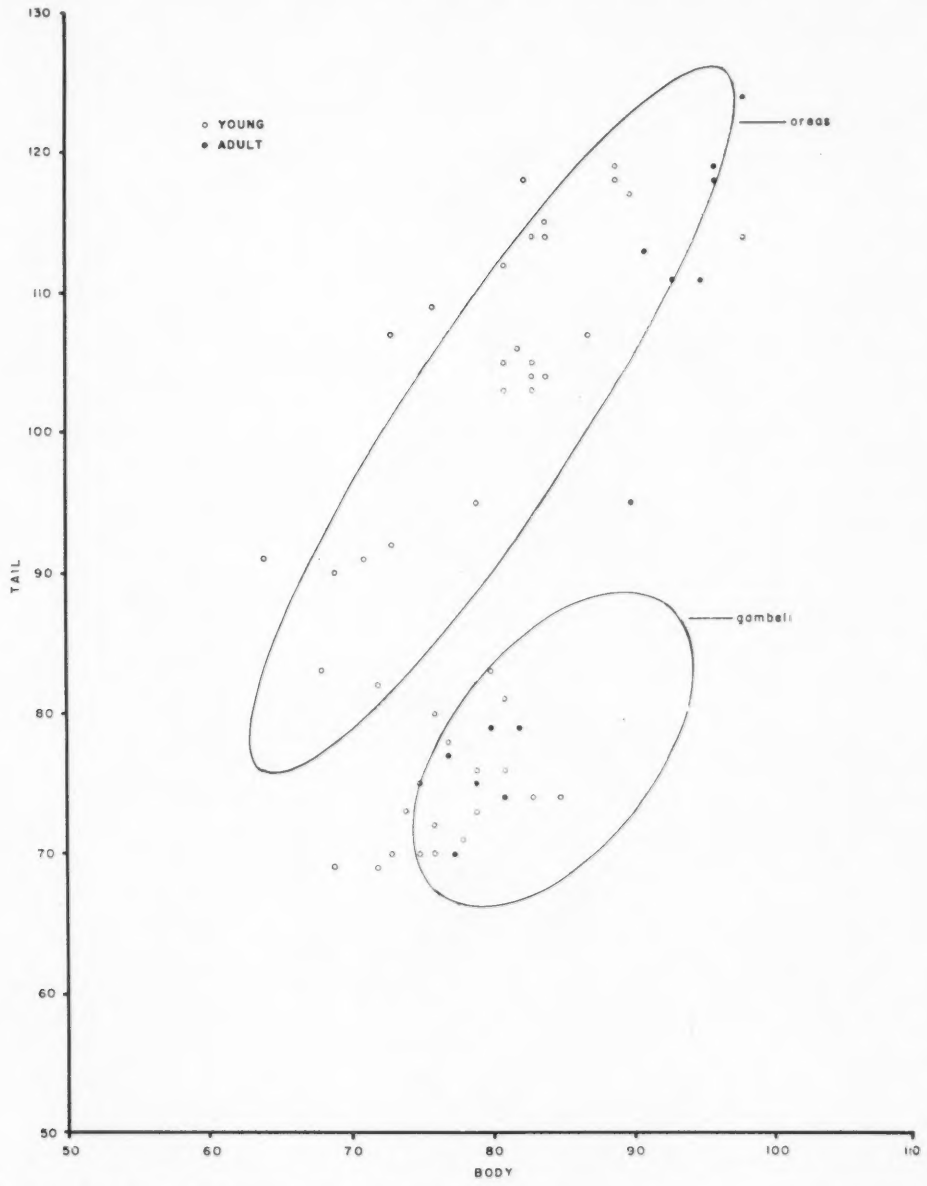


FIG. 6. Scatter diagram of tail length/body length data for *Peromyscus oreas* and *P. maniculatus gambeli* from American Forks. The equal-frequency ellipses for *P. oreas* from Wright's Ranch and for *P. m. gambeli* from River Bend have been superimposed.

County, included thirty-nine *oreas*, nine *gambeli*, and two questionable. The tail/body data for my collection from American Forks, Yakima County, are shown in figure 6. Equal-frequency ellipses for *oreas* from Wright's Ranch and *gambeli* from River Bend have been superimposed on these data, as a means of comparing the samples. The points fall into two distinct groups, corresponding

roughly to the positions of the two ellipses. The *gambeli* from American Forks are younger than those from River Bend, explaining in part the poorness of fit. The American Forks sample includes thirty-two *oreas*, twenty-four *gambeli*, and one questionable, showing very clearly the distinctness of these two forms.

2. *oreas* and *artemisiae*

Osgood conceived of *artemisiae* as

> an aggregation of intermediates, but sufficiently constant and restricted in range to merit recognition. . . . In a way, it connects the long-tailed and the short-tailed forms of the *maniculatus* group. . . . The gradation from *gambeli* via *artemisiae* to *oreas* seems to be complete, although at certain localities representatives of each may be found apparently preserving distinctness (1909: 59).

Elsewhere he says that "*oreas* appears to intergrade with *arcticus* [= *borealis*], most of the intermediate specimens having been referred to *artemisiae*" (1909: 53).

His concept of intergradation is brought in question when he says that specimens from Field, Glacier, and Golden, B. C., are "approaching *oreas* and *arcticus*" (p. 60). These localities are in the eastern part of the province, hundreds of miles from the range of *oreas*. Presumably the specimens referred to are *P. m. alpinus* Cowan, which resembles *oreas* in some respects. Osgood lists *artemisiae* from Hope, B. C. This locality is at the western foot of the Cascades, far from the range of this race.

Anderson (1946) and Dalquest (1948) also state that *artemisiae* intergrades with *oreas*, but do not mention specific localities where this occurs. Carl, Guiget, and Hardy (1952: 74) say that *oreas* "occupies the greater part [of Manning Park], intergrading with *Peromyscus m. artemisiae* (Rhoads) in the Goodfellow Creek area to the east where specimens of both races were secured." They do not say that they found intermediate specimens.

The distribution of *oreas* and *artemisiae* in northern Washington is much like that of *oreas* and *gambeli* farther south, *oreas* being found in the higher Cascades, *artemisiae* in the high country east of the mountains, and both forms in intermediate areas. A few questionable specimens may be hybrids. Apparently *oreas*, *artemisiae*, and *austerus* all occur in the Skagit River valley just west of the Cascade crest. This is the only area west of the crest from which I have seen *artemisiae*.

The same geographic relations between these races were found on the east side of the Cascades of southern British Columbia and of the British Columbia Coast Range farther north. Mixed populations were found at a number of places, including Goodfellow Creek (thirty *oreas*, twenty *artemisiae*, one questionable), and Copper Creek (five *oreas*, thirty-three *artemisiae*, one questionable), both on the upper Similkameen River. The largest sample was from Wright's Ranch, where eighty-seven *oreas*, 101 *artemisiae* and four questionable mice were collected. Most of the Wright's Ranch data are plotted in figure 7, with the equal-frequency ellipses that were calculated for them. This locality is on the eastern edge of the *oreas* range.

Most of the mice collected in the *oreas-artemisiae* area were easily identified, but individuals from a number of areas were questionable, and a few entire samples could not be satisfactorily diagnosed. The most puzzling of these was from Pinewoods, on the Similkameen River a few miles above Goodfellow Creek. This large sample, taken as a whole, cannot be explained as a mixture of two species, with or without hybrids, or as an intergrade. It seems probable that most of the puzzling features of this sample are artifacts, resulting from different methods of measurement by different collectors. Almost all of the mice that I collected there myself were clearly *oreas*, but there were several that may have been hybrids.

3. *oreas* and *austerus*

The relation of *oreas* to *austerus* has been studied more extensively than its relation to any other race, but it has been a frequent puzzle to systematists. This is at least partly because *austerus* is more like *oreas* than are the interior races. Osgood (1909: 52–53) commented that the systematic relationship of these two forms

> is difficult to understand. . . . It is already known that *oreas* and *austerus* occur together at a number of localities and apparently maintain their respective characters. At other places only one form has thus far been found, at others extremes of both forms and intermediates occur, and at still others intermediates only. . . . Specimens which appear to be intermediate between *oreas* and *austerus* may in reality represent special differentiations of the one or the other showing accidental parallelism.

This confusion still exists, and these two forms are reported by different workers as intergrading or not intergrading at various localities. Taylor and Shaw (1929) say that they apparently occur

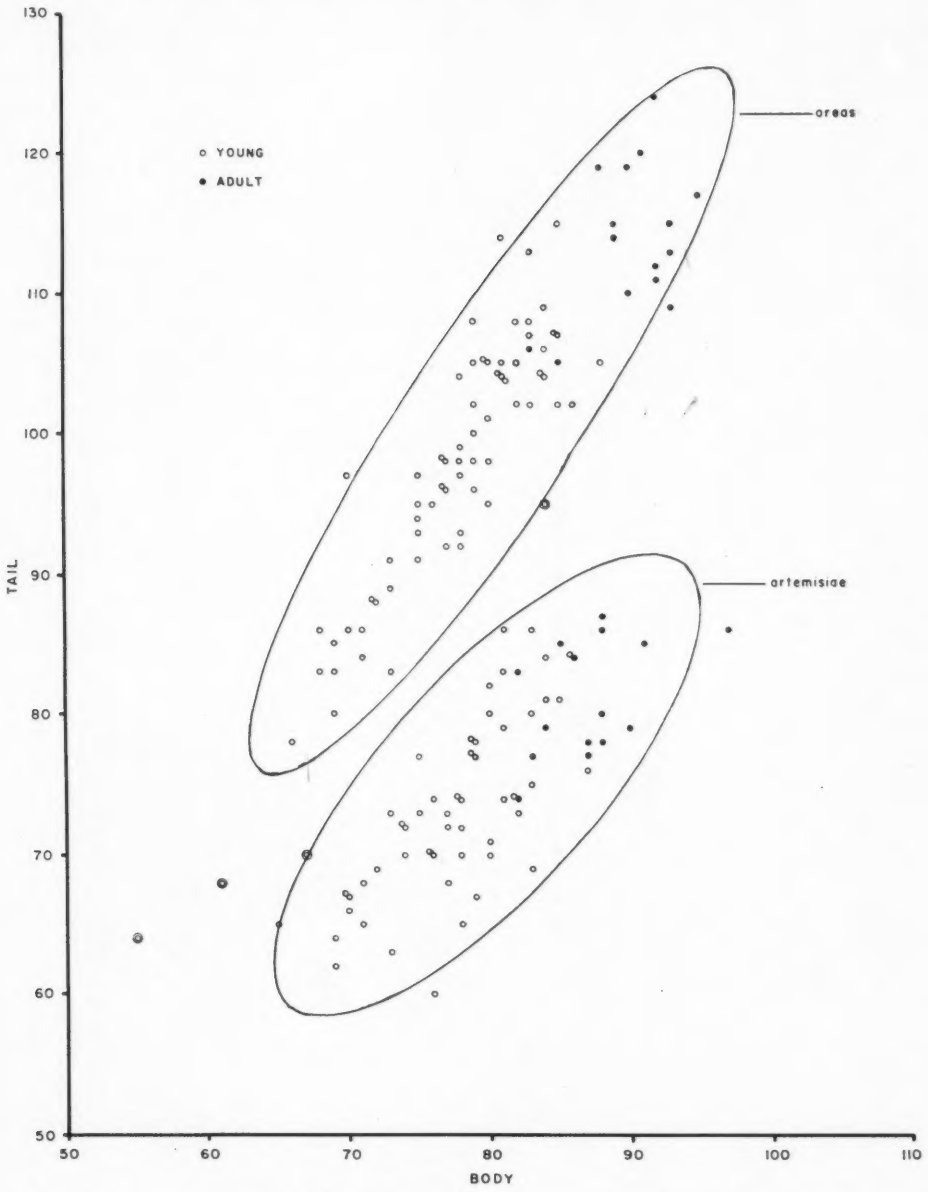


FIG. 7. Scatter diagram of tail length/body length data for *Peromyscus oreas* and *P. maniculatus artemisiae* from Wright's Ranch. These data have been fitted with equal-frequency ellipses.

together over a wide area. Dice (1932) says that Gaige collected both races at Lake Cushman on the Olympic Peninsula, apparently without finding intergrades. Dice himself (1949) collected both races at several localities in the Puget Sound region: Svihla and Svihla (1933) found both races occupying the same habitat on the Olympic Peninsula without intergrading, and

similar results are reported by Dalquest (1948: 93). Fox (1948) believed that the two forms interbreed, but not freely. Johnson and Ostenson (1959) have found no intergradation.

Intergradation in British Columbia has been reported by several workers. Anderson (1946) says that on the western slopes of the Cascades east of the coastal plain *orcas* intergrades with *austerus* in some areas. Carl *et al.* (1952) believe that these races may intergrade in the Hope area, as one specimen taken there shows characters of both races. According to Cowan and Guiguet (1956: 188) "there is gradual blending between *austerus* and *orcas* between Aldergrove and Cultus Lake along the International Boundary and up the slopes of the adjacent hills." McCabe and Cowan (1945) say that *orcas* and *austerus* occur together at Loughborough Inlet, apparently without intergradation.

In Washington *austerus* is found throughout the Puget Sound Lowlands, but does not seem to extend into the Cascade Mountains to the east at all. It is absent from the northwest corner of the Olympic Peninsula. *Orcas* occurs throughout the western Cascades and the lowlands and coast region, except apparently in parts of the Puget Sound region. Samples from various localities include both forms, for example Cathlamet (Wahkiakum County), Hwaco (Pacific), Aberdeen (Grays Harbor), Dungeness Hatchery (Clallam), Shelton (Mason), near Yacolt (Clark), near Chehalis (Lewis), Tenino (Thurston), Bothell (King), and Mount Vernon (Skagit). The number of intermediates is much smaller than the number of positively identified specimens.

Only *austerus* has been found near sea level on the southern British Columbia coast, but *orcas* occurs in the adjacent mountains. Both races were found living together at certain altitudes on the mountainsides. This is in contrast to the situation in Washington, where *orcas* was found at most coastal stations and *austerus* was not found in the mountains at all. On Mount Seymour, just north of Vancouver, only *austerus* was found up to 2,200 feet. Both races were found at 2,500–2,900 feet, and only *orcas* was found above that. About one-third of the mice from the zone of overlap were of questionable identity, but most were typical of their race. Such distributional overlap was found at a number of stations at intermediate elevations around the Fraser River delta.

Farther north (Bute Inlet, Loughborough Inlet) both *orcas* and *austerus* have been found at sea level. *Austerus* reaches the northern limit of its range a short distance north of Loughborough Inlet, and only *orcas* is found above there.

Several samples from localities around the edge of the Fraser delta are difficult to interpret. The sample from Hope, at the foot of the Cascade Mountains, shows a mixture of characters which I cannot explain on any basis. A small sample from near Haney, also at the foot of the mountains, seems to be intermediate between *orcas* and *austerus* in tail length (89–105 mm.) and hind foot length (21–23 mm.). This suggests that the population there is an intergrade, but arguing against this is the low value for the slope of the standard major axis ($a = 1.007$). This is lower than the values for *austerus* (table 1), although an intergrade population should have a higher value.

Similarly puzzling is the sample from Loon Lake, five miles north of Haney at 1,150 feet elevation. This sample is heterogeneous, and some specimens show characteristics of both *orcas* and *austerus*. Tail lengths reach 105 mm., foot lengths 24 mm. There are no higher elevations for miles around and it seems unlikely that there is an *orcas* population nearby to interbreed with *austerus*. The Loon Lake population probably is a local deviation from the typical *austerus* condition.

4. *orcas* and *macrorhinus*

McCabe and Cowan (1945) have treated *macrorhinus* and neighboring forms in some detail, but the available collections are not sufficient to permit final analysis of a situation as complex as this. All authorities have said that *macrorhinus* intergrades with *orcas*. Osgood (1909) placed the area of intergradation at Rivers Inlet, where some individuals could be referred to one or the other of these races while others were intermediate. Anderson (1946) reported intergradation farther north, in the Bella Coola area, but Cowan and Guiguet (1956) consider these specimens to be intergrades between *macrorhinus* and *artemisiae*. McCabe and Cowan (1945) identified mice from Kingcome Inlet, south of Rivers Inlet, as intergrades between *macrorhinus* and *orcas*. They suggest that these races may be in contact over a long distance, *orcas* occupying the mountains and *macrorhinus* the adjacent coast. I have done no field work in the *macrorhinus* area.

Apparently Rivers Inlet, just north of the northern end of Vancouver Island, is the point of

contact between *oreas* and *macrorhinus*. The scatter of tail/body points (fig. 8) is almost circular, unlike the elongate form characteristic of such figures. This suggests that the sample may be a mixture of races. Equal-frequency ellipses for *oreas* from Neah Bay, Washington, and for *macrorhinus* from the central British Columbia coast have been superimposed on this graph, and together include all but two of the points. As would be expected if the sample is mixed, the points are more dense where the ellipses overlap, but the difference is too great to be explained on this basis alone. The area of overlap is less than half the total area of the combined ellipses, but it includes fifty-eight of the sixty-five points within the ellipses, suggesting a population intermediate between the two races.

Ten of these mice have white spots on the tail, a character found occasionally in *oreas* but not in the other races. All of these mice are in the *oreas* ellipse.

Although this population has been called an intergrade, it seems at least equally likely that it is a mixture of two distinct forms.

Peromyscus from Kingcome Inlet, south of Rivers Inlet, have also been called intergrades, but I believe they are pure *oreas*. The only resemblance to *macrorhinus* is in body length, which averages slightly greater than in typical *oreas*, but a few *oreas* samples from as far south as Washington have body lengths as great as the Kingcome Inlet sample. The tail/body data for this sample fit the ellipse for Neah Bay *oreas* fairly well, but fit the one for *macrorhinus* poorly. The slope of the standard major axis is $a = 1.353$, compared to 1.013 for *macrorhinus* and a minimum of 1.273 for known *oreas* samples.

The relations of *oreas* to *macrorhinus* are less clear than to any of the other races it contacts. The close similarity between these forms, the geographic variability of *macrorhinus*, and the paucity of collections from the area make it impossible to come to any satisfactory conclusions at present. However, there seems to be no reason to think that these forms intergrade.

5. *gambeli* and *austerus*

These races presumably intergrade along the Columbia River in Washington (Fox, 1948). Dice (1949) has reported that a stock of *Peromyscus* from Bingen is intermediate between them. Apparently neither race reaches the moun-

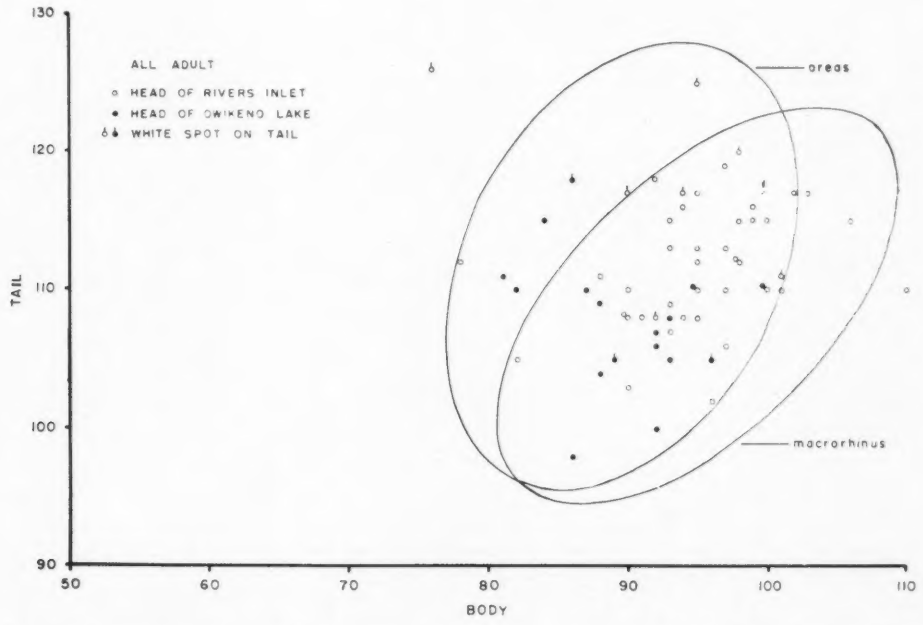


FIG. 8. Scatter diagram of tail length/body length data for *Peromyscus* from Rivers Inlet. The equal-frequency ellipses for *P. oreas* from Neah Bay and *P. m. macrorhinus* from Central Coast have been superimposed.

tain passes farther north. Snoqualmie Pass (3,010 feet) is the lowest, and collecting at stations several miles east and west of there yielded only *orcas*, though *gambeli* was taken at higher elevations in other areas.

6. *gambeli* and *artemisiae*

The *maniculatus* populations of eastern Washington exhibit much microgeographic variation within a narrow range of total variation. Subspecific designations probably mean little here, but specimens that I have examined from northeastern Washington and from the Blue Mountains of southeastern Washington seem to be slightly larger and darker than those from the central part of the state, and probably should be separated from them as Dalquest (1948) has done. Samples from near the Columbia River in northern Grant County consist entirely of *maniculatus*. They are labeled "*gambeli*" but fit the *artemisiae* ellipses better. This area is near the *artemisiae-gambeli* border as drawn by Dalquest.

7. *artemisiae* and *austerus*

The Cascade Mountains are separated from the British Columbia Coast Range by the canyon of the Fraser and Thompson Rivers, which forms a low-level corridor from the dry interior to the humid coast. The mountains on both sides of the canyon exceed 6,000 feet elevation, but the maximum elevation of the river is about 1,000 feet. Although *orcas* is the only form in the mountains on both sides, it is almost absent from the canyon itself. The canyon is occupied by *maniculatus*, which also reaches for some distance up into the mountains.

Ashcroft, near the upper end of the canyon, is the type locality of *artemisiae*. Emory Creek, near the lower end, is just a few miles from the Fraser delta, which is occupied by *austerus*. These two races intergrade along the canyon. Figure 9 shows the fairly uniform decrease in tail length from south to north, from an average of about 86 mm. at Emory Creek to 70 mm. at Ashcroft for young, and from 94 to 76 mm. for adults. Body length shows a similar cline, but it is opposite in direction, as would be expected, and less regular. It ranges from 78 to 85 mm. for young, and from 84 to 90 mm. for adults.

Samples of similar size show similar variability, and there is a general cline in maximum and minimum sizes, as well as in means. This indicates that this is true intergradation, rather than hybridization or a mingling of distinct populations. This is the only clear example of intergradation encountered in this study.

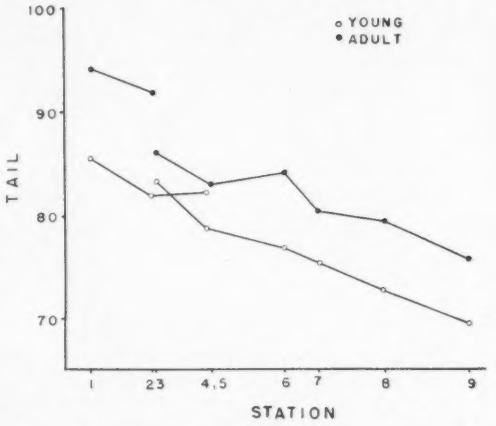


FIG. 9. Change in tail length of *Peromyscus maniculatus* along the Thompson-Fraser Canyon. The stations are spaced on the abscissa in proportion to their actual distance apart. Spences Bridge is on the west side of the Thompson River; Emory Creek, Spuzzum, and North Bend are on the west side of the Fraser River; and all other stations are on the east side of the Thompson-Fraser. (1) Emory Creek, at south end of canyon (2 young, 3 adult). (2) Spuzzum (20, 13). (3) Alexandra (19, 17). (4) North Bend (4, 0). (5) Boston Bar (22, 4). (6) Blue Lake (17, 16). (7) Lytton (14, 4). (8) Spences Bridge (4, 2). (9) Ashcroft, at north end of canyon (8, 3).

Both the Fraser and Thompson Rivers are large and swift and undoubtedly act as effective barriers to *Peromyscus*. There is some indication that the mice are different on opposite sides of the river, but the samples are not adequate to prove this.

Both *artemisiae* and *austerus* occur within a few miles of Allison Pass, and they may meet at places along the Cascade summit. Only *orcas* was taken at Allison Pass and Gibson Pass, but *artemisiae* apparently has crossed the summit and occurs in the Skagit River watershed in northern Washington. It may be expected to intergrade with *austerus* there.

8. *artemisiae* and *macrorhinus*

It is probable that *artemisiae* from the interior and *macrorhinus* from the coast meet somewhere in or near the central Coast Range, presumably intergrading where they come in contact. The only sample that seems to include both forms is

from Stuie, in the Bella Coola valley about thirty miles from salt water. Stuie is surrounded by high mountains, but its elevation is only 460 feet. Eleven specimens from here are typical *artemisiae* and eight are typical *macrorhinus*. Three specimens are somewhat intermediate, and probably are hybrids. This sample suggests that these races meet and hybridize but do not intergrade.

9. *austerus* and *macrorhinus*

These races do not come in contact at any point.

III. EXPERIMENTAL HYBRIDIZATION

The results of laboratory breeding experiments are not valid taxonomic criteria and cannot be used in determining the relationship of different forms. Only field data, i.e. the occurrence or absence of intergradation or hybridization in nature, are acceptable for this purpose. However, laboratory studies may be of value in determining the mechanisms responsible for reproductive isolation which has been demonstrated in the field.

Several workers have studied the behavioral and reproductive relations of various races of *Peromyscus* in the laboratory (Dice, 1940*a*; Blair, 1954). Such work has shown that under the experimental conditions the members of different species groups of *Peromyscus* (as distinguished by Osgood, 1909) are completely intersterile. No inter-group hybrids have been produced. Two species in the same species group may be completely inter-fertile or may show reduced interfertility. In sociality tests, mice tend to choose mates of their own species. Subspecies of the same species interbreed freely, and show no social discrimination.

Blair (1947) reported crosses of *oreas* and *P. m. blandus* Osgood of New Mexico, but his *oreas* stocks were later determined by Dice (1949) to be *austerus*. The measurements presented by Dice clearly place the animals in this race, rather than in *oreas*. Dalquest (1948) attempted without success to cross *oreas* and *austerus*, but he apparently had no controls. Dice (1949) bred stocks of *Peromyscus* from various localities in Washington in his laboratory. *Austerus* bred well, but *oreas* bred poorly and no *oreas* × *maniculatus* crosses were obtained. *Austerus* interbred with *blandus*, but *oreas* failed to do so. Liu (1954) has reported matings between *oreas* and *P. m. gracilis* (le Conte) of the Midwest. These matings usually failed to produce offspring, and the only hybrid to reach adult age, a male, was sterile.

Dice feels that because *oreas* and *austerus* occur together in nature, apparently without interbreeding, and because they failed to interbreed in the laboratory it is probable that there is some kind of fertility barrier to their interbreeding. He suggests that *oreas* and *austerus* may actually "represent two different species, which in this region do not interbreed, but whose ranges here partly overlap. Such a hypothesis could best be tested by making matings between positively identified individuals of both forms" (1949: 23).

To clarify the reproductive relationships of *oreas* and *maniculatus* I made a number of experimental matings, but the breeding record of the colony was poor. The *oreas* failed to breed at all. Both *austerus* and *artemisiae* bred with members of their own race. Two female *austerus* produced young by *artemisiae* males, one of them twice. The hybrids seemed to be fully as viable as the offspring of single-race matings. One female hybrid produced young when backcrossed to an *austerus* male, and another produced two litters by an *artemisiae* male.

These limited results suggest that *austerus* and *artemisiae* are completely interfertile and produce fertile hybrids. This agrees with the results obtained by other workers, mentioned above, who found full interfertility between subspecies of the same species. It also is in accord with the field data, which show intergradation of these races in the Fraser Canyon.

IV. DISCUSSION OF SYSTEMATIC RELATIONS

The ranges of *Peromyscus oreas* and the adjacent subspecies of *P. maniculatus* overlap widely. Within this zone of overlap both species have been taken at many stations. At some stations both species and apparently intermediate individuals have been taken, suggesting that these forms may hybridize under certain conditions. No definite intergrade population has been found, but certain samples suggest intergradation, e.g. those from Hope, Haney, and Loon Lake. The interpretation of such samples is complicated by the fact that no two of them show the same characteristics.

It seems probable that some intermediate specimens are hybrids or intergrades. This raises a problem of nomenclature. Races which hybridize only rarely in nature are considered distinct species, while races which merge in a zone of intergradation wherever they come in contact are con-

sidered conspecific. There is every degree of intermediate condition, though, and no rule is available for interpreting them.

The races of *Peromyscus* interact in a variety of ways, and any nomenclatural decision about some situations will necessarily be arbitrary. Few cases of intergradation or hybridization have been carefully analyzed. One of the best such analyses is Sumner's (1929) study of intergradation between two races of *P. polionotus* (Wagner) in Florida. He found a narrow zone in which most individuals were intermediate between the two races. Dice (1940*b*) found a broad zone of intergradation between *P. m. bairdi* (Hoy and Kennicott) and *P. m. osgoodi* Mearns in North Dakota. Intergradation was irregular and in places the trend was reversed, but apparently most of the samples showed similar variability.

Such intergradation is known to occur between various of the races comprising the great complex of *P. maniculatus*, but some of the races apparently meet without intergrading. Dice (1931) reports that *P. m. bairdi* and *P. m. gracilis* occur together in much of Michigan without interbreeding, and Murie (1933) found *P. m. osgoodi* and *P. m. artemisiae* living in the same area in Montana without intermediates. In both cases the races are largely ecologically isolated, but there is at least some direct contact between individuals of the two races. These races are considered conspecific because they are thought to be connected by a series of other races with which they do intergrade.

Apparent hybridization between two species of the same species group has been described by McCarley (1954). *P. leucopus* and *P. gossypinus* meet in many places over a wide front from Virginia to Texas. In some areas no hybrids have been found, in others occasional hybrids occur, and in at least one area hybridization is frequent. This seems to be similar to the relations of *oreas* and *maniculatus* in the Northwest.

Whatever the correct interpretation of the apparent cases of hybridization and intergradation between *oreas* and *maniculatus*, there is no evidence that these races have established a common gene pool or that they are in process of doing so. Instead, we find that although they are sympatric over large areas they still maintain their respective identities. *Maniculatus* is divided into several geographic races which exhibit some variation within themselves, but none of this variation is correlated with the presence or absence of *oreas*. *Oreas* is quite uniform throughout its range. It seems desirable to remove *oreas* from the species *P. maniculatus* and refer to it as *P. oreas* Bangs.

ECOLOGICAL RELATIONS

1. REGIONAL ENVIRONMENT

The dominant topographic feature of the Pacific Northwest is the great chain of mountains that parallels the coast—the northern Cascade Range extending from the Columbia River to the Fraser River and the British Columbia Coast Range north of the Fraser. The crest line is at 6,000–8,000 feet, but many peaks exceed 10,000 feet. Both ranges are up to 100 miles wide, and are penetrated by low, narrow river valleys. On the west the Cascades are bounded by lowlands, but the British Columbia Coast Range descends almost directly into the sea. To the east the mountains are bounded largely by high, rolling plateaus.

As would be expected in an area of such topographic diversity, the climate of the Northwest shows much regional and local variation. In general, areas west of the mountains have mild, rainy climates while those east of the mountains have dry climates with temperatures lower in winter and higher in summer than on the coast. In the mountains the summers are short and cool, and winter snowfall is heavy. Winter is the time of maximum precipitation, usually in the form of rain on the coast, of snow in the mountains and interior. Summers usually are dry and sunny throughout the region except on the exposed coast, where rain may fall almost every day.

In keeping with the topographic and climatic diversity of the region, there is a wide range of biotic communities, from the dense forests of the coast to the semi-arid grasslands of the interior. The climax vegetation of the western lowlands is great forests of western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). Douglas fir (*Pseudotsuga taxifolia*) is subclimax. These forests have been largely felled and replaced by open farmland or deciduous forests of alder (*Alnus* sp.), broadleaf maple (*Acer macrophyllum*), and other trees and shrubs. Wooded areas usually have dense undergrowth. Similar forests extend well up onto the western slopes of the mountains.

Higher elevations are occupied by subalpine forests, primarily of mountain hemlock (*Tsuga mertensiana*) and yellow cedar (*Chamaecyparis nootkatensis*) on the coast, and of Engelmann spruce (*Picea engelmanni*) and alpine fir (*Abies*

lasciocarpa) in the interior. These forests lack the dense understory of shrubs that is found in the coast forests. The highest parts of the mountains have alpine meadows but no forests.

The region just east of the Cascades is relatively dry. The main vegetation types are grassland, ponderosa pine (*Pinus ponderosa*), and Douglas fir, in order of increasing wetness. The forest floor usually is open. Farther north, subalpine forests extend for some distance east of the Coast Range.

II. HABITAT RELATIONS

Peromyscus was found in almost all terrestrial habitats in the region where I collected, but it varied greatly in abundance in different habitat types. I attempted to trap in all of the principal habitats, keeping each trapline within one habitat type as much as possible. The samples are too small to permit drawing detailed conclusions, but a general picture emerges fairly clearly—where *P. oreas* and *P. maniculatus* occur in the same area they tend to occupy different habitats.

1. *oreas* and *gambeli*

These races are sympatric on the eastern side of the Cascades in a zone varying from several miles to at least twenty miles in width. In the Tieton River valley a wide range of forest types occurs in a small area and the change from montane to interior forests is fairly abrupt. Both races were found at Clear Lake (3,300 feet), in this zone of ecological transition. Only *oreas* was found in wet forest. One line in mesic forest took only *oreas;* another took more *gambeli* than *oreas*. One line in dry forest took only *gambeli*; but another took mostly *oreas*, probably because there was a dense population of that race in wet forest a short distance away. *Oreas* populations in wet forest were much more dense than any *gambeli* population. Judging from the trap records and the distribution of forest types it seems that the vertical overlap of these races in the Tieton valley is less than nine hundred feet, and the horizontal overlap less than four miles (table 2).

In the American River-Naches River valley farther north forest transition is more gradual and the overlap of races is correspondingly wide—over twenty miles horizontally and at least seventeen hundred feet vertically. The highest locality for *gambeli* was reported by Dice (1949). He found both races at Lodgepole Camp (4,500 feet) living in a lodgepole pine-white pine-larch-spruce forest. At American Forks (2,800 feet) farther east both subalpine forest and dry forest were found. Here *oreas* and *gambeli* were found living together in most habitats, but in some habitats only one race was found. Usually *oreas* was the only or more abundant inhabitant of the wetter places, while *gambeli* was alone or dominant on dry sites.

In the Yakima River valley, farther north, there is a uniform gradual change in forest type, rather than a complex intermixture of distinct types. Both *oreas* and *gambeli* were taken near Easton (2,200 feet). Fairly typical dry forest begins a few miles to the east. Trapping has not been extensive enough in this valley to show the distributional limits of these races, but the zone of overlap probably is narrow.

Table 2 shows that the zone of overlap may be at entirely different altitudes in areas that are close together. The common factor of the zone of overlap in each of these valleys is the occurrence of mixed or intergrading montane and interior forest. The occurrence of such forests is determined by a complex of climatic and edaphic conditions which vary with the geology and topography of the area.

The importance of topography is suggested by comparing the maximum elevation reached by *gambeli* in each valley with the height of the highway pass at the head of the valley. The higher the pass, the higher *gambeli* extends. In these valleys, it seems to reach to within 500–1,000 feet of the height of the pass. The height of the pass is an indication of the general height

TABLE 2

ALTITUDINAL DISTRIBUTION OF *P. oreas* AND *P. maniculatus* IN VALLEYS ON THE EAST SIDE OF THE CASCADES

Valley	Height of pass	Probable minimum elevation of *oreas*	Probable maximum elevation of *maniculatus*	Vertical overlap	Horizontal overlap
Tieton	4500 ft.	3100 ft.	4000 ft. (*gambeli*)	900 ft.	4 mi.
American	5440 ft.	2800 ft.	4500 ft. (*gambeli*)	1700+ ft.	20+ mi.
Yakima	3010 ft.	2000 ft.?	2300 ft. (*gambeli*)	300 ft.?	3 mi.?
Similkameen	4400 ft.	2800 ft.	4000+ ft. (*artemisiae*)	1200+ ft.	5–10 mi.?

of the mountain barrier in that area, and the higher barriers provide greater protection from the climatic influence of the coast.

2. *orcas* and *artemisiae*

The geographic and ecological relations of these races are similar to those of *orcas* and *gambeli*. The distribution of these races was studied in the Similkameen River valley of southern British Columbia. There is an extended and irregular transition from subalpine forest to dry forest along this valley. The valley is not a good transect, because it runs more north than east and the mountains are never far away. *Orcas* occurs in the mountains west of the river, but probably does not occur east of the Similkameen-Pasayten Rivers.

Only *orcas* was found at Allison Pass (4,400 feet), and it was found in all habitats, including moist subalpine forest, dry open lodgepole pine (*Pinus contorta*) forest, a talus slide, and an open burn. Ground cover varied from almost none to abundant vegetation and logs. Both races were found a few miles farther east.

At Goodfellow Creek (3,400 feet) *orcas* was still more common than *artemisiae*. Moist sites near the river yielded only *orcas*. Engiemann spruce was a conspicuous component of the forests on these sites. A talus slide yielded only *artemisiae*, and a dry hillside forest yielded a great majority of *artemisiae*. Slightly wetter hillside sites yielded approximately equal numbers of the two races, as did a dry lodgepole pine woods by the river.

At Copper Creek (3,100 feet) the subalpine elements of the vegetation are further reduced and the dry forest elements more prominent. All habitat types yielded *artemisiae*, including types similar to ones that had yielded only *orcas* at Goodfellow Creek. *Orcas* was taken in only one place, which was the wettest and most densely vegetated at this station. This was the most productive site at Copper Creek, and yielded approximately equal numbers of both races.

The easternmost record of *orcas* is from Wright's Ranch (2,800 feet), three miles southwest of Princeton. This is a broad area of low relief between the mountains and the deep valleys of the Similkameen and Tulameen Rivers. Four principal habitat types are present—open grassland, ponderosa pine, Douglas fir, and Engelmann spruce, in order of increasing wetness. The first three occupy large areas, but spruce is confined to a few sheltered sites.

Initial trapping showed that *artemisiae* occupied most of this area, being absent only from the driest sites and from the wettest site studied. This wet site was the only place where *orcas* was found, but it was found here in greater density than *artemisiae* ever reached (10 *orcas* in 80 trap nights here, vs. 12 *artemisiae* in 360 trap nights on other lines). This site was in a large ravine with the densest shrub cover in the area and one of the few spruce stands. The other sites trapped were largely lacking in good cover, but some had as much as sites which had yielded *orcas* at other stations.

The spruce ravine where *orcas* was trapped also was the only place in the area where the redback vole (*Clethrionomys gapperi*) and the shrew-mole (*Neurotrichus gibbsi*) were found. *Clethrionomys* often was found associated with *orcas* throughout the range of the latter, but rarely with *maniculatus*. This ravine apparently is the only place in British Columbia where *Neurotrichus* has been found east of the Cascade summit.

This station provided the most clear-cut example of ecological isolation between *orcas* and *maniculatus* that was encountered, and it seemed desirable to give further attention to the relations between the two species here. Most of the work was concentrated on the spruce ravine where *orcas* had been found and on the surrounding hillsides. The objectives of this work were to obtain a large sample of both species for systematic analysis, to determine in detail the habitat distribution of the species in and around the ravine, and to carry out a field experiment to determine the causes of the observed habitat restriction.

The ravine is roughly 900–1,000 feet long, 375 feet wide at the south, and 75 feet deep. It faces

FIG. 10. Looking south toward the ravine at Wright's Ranch.

FIG. 11. *Peromyscus oreas* habitat in the ravine at Wright's Ranch.

north, opening onto a cultivated field through which a small creek flows (fig. 10). The ravine itself has no surface water, but is marshy in a few spots. The floor of the ravine is wide and fairly flat, rising irregularly toward the head. Behind the ravine is a level hilltop, with ponderosa pine, lodepole pine, and Douglas fir.

The vegetation of the ravine is denser than that of any other part of the ranch, but it varies greatly from place to place. The lower parts are wetter and have denser vegetation than the upper parts. Logging has thinned the timber and in places completely removed it. Early in the study the ravine was frequented by cattle during part of the year and they had greatly damaged the shrubs and herbs, but by the end of the study they had been excluded and the underbrush was thicker.

Engelmann spruce is the most characterstic tree here. Near the mouth it forms small stands of trees 3–10 inches in diameter. Farther up it is less common, but there are a few very large trees. There is no spruce regeneration. There are several clumps of large aspen (*Populus tremuloides*), and many seedlings. Small Douglas fir are scattered throughout and are dominant near the head of the ravine. Less than half of the ravine is under tree canopy.

In the open areas in the middle and lower parts of the ravine are dense stands of shrubs, the most abundant being red osier (*Cornus stolonifera*) and black twinberry (*Lonicera involucrata*) (fig. 11). Small willows (*Salix* sp.) and mountain alder (*Alnus tenuifolia*) are found in places. Cow parsnip (*Heracleum lanatum*) is the most conspicuous herb in the wetter areas, reaching seven feet in height.

Small logs are abundant in some places, absent from others. There is some brush scattered on the ground, and a few large brush piles. There are no rocks in the ravine.

A typical soil profile in the areas of dense vegetation shows two inches of surface litter underlain by almost a foot of fine friable humus. The humus is dark brown, loosely bound by roots and mycelia. Beneath the humus is fine mineral loam. The soil in the less heavily vegetated parts of the ravine and on the hillsides consists of weathered loam under a thin layer of litter, with little humus content.

In short, the ravine is a very fertile area, presumably with high food production. The amount and kind of protective cover varies greatly from place to place. Prominent cover types include dense patches of herbs, dense stands of osier and other shrubs, and stands of spruce and other trees with little ground cover except scattered logs and brush.

The area where *oreas* was trapped corresponded closely to that occupied by the denser vegetation (fig. 12). It was taken in the woods near the mouth of the ravine, on the ravine floor throughout its lower half, and for a short distance along the creek west of the ravine. The only areas without dense vegetation that yielded *oreas* were the upper half of the ravine and the lower part of the western hillside, where a few mice of this species were taken among scattered pines and grass. No *oreas* were taken on the eastern hillside, on the hill behind the ravine, among the aspen in the open field, or along the creek east of the ravine. The *oreas* taken on the western slope may have been residents of the ravine bottom foraging on the hillside.

The distribution of *artemisiae* was almost complementary to that of *oreas*. It was found in

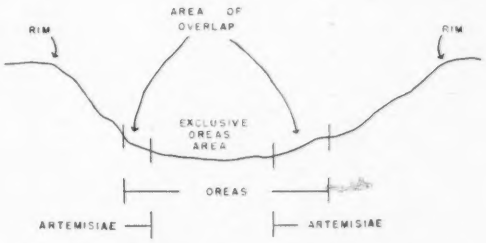


FIG. 12. Schematic cross-section of the ravine at Wright's Ranch.

small numbers completely encircling the ravine—in the brush and trees near the mouth, on the hillsides flanking the ravine, on the hill behind the ravine, and among the aspen along the creek in the field. It also was taken in the upper parts of the ravine, where the vegetation is sparse and *oreas* is rare. No *artemisiae* were taken by the creek west of the ravine, where *oreas* was found, but a few were taken in dry sites within thirty feet of the creek.

There was a zone around the ravine in which both species occurred. This zone seemed to be narrow, perhaps only a few yards wide, on the eastern side and along the mouth of the ravine, but somewhat wider on the western side and in the upper part of the ravine.

Trapping outside the ravine revealed that this population of *oreas* was quite isolated from all others. The only *oreas* trapped outside the ravine were a few taken along the creek to the west. From trapping and observations in other parts of the region it seems that there is no other *oreas* population within several miles.

The small and isolated nature of this population made it possible to attempt trapping all of the *oreas* present. During the intensive trapping of August, 1957 (table 3), the last several hundred trap nights in good *oreas* habitat yielded only four *Peromyscus*, all of them *oreas*. Two nights of trapping in the same habitat seven weeks later yielded three *oreas* and two *artemisiae*. Apparently there was no reproduction during this time, and if we assume no immigration the minimum *oreas* population at the beginning of the 1957 trapping program was seventy-two. The actual population size probably was not much greater than this. The lower half of the ravine, which included the best *oreas* habitat, is about three acres in area, and yielded about forty-five *oreas*, for a population density of fifteen per acre.

The trapping program was so irregular in both space and time that only a rough estimate of the relative abundance of the two races is possible. In the first three nights of trapping sixty-nine traps set in the best *oreas* habitat took twenty-seven *oreas* and two *artemisiae*. Later ninety traps set on the eastern hillside and the hill behind the ravine in typical *artemisiae* habitat took one *oreas* and eleven *artemisiae* in three nights. The highest local concentration of *artemisiae* was found in the bushes and aspen along the creek in the open field east of the ravine, where sixteen traps took ten mice of this race in three nights.

It was clear in the field that *oreas* was in greater density in the center of its area, where no *artemisiae* occurred, than in the zone of overlap. *Artemisiae*, though, seemed to be more abundant in the zone of overlap than in the area outside the ravine, where no *oreas* occurred. In the zone of overlap the two forms were in roughly equal density, but *oreas* in its exclusive area was in much greater density than *artemisiae* in its.

TABLE 3

TRAPPING RESULTS FROM IN AND AROUND THE RAVINE AT WRIGHT'S RANCH.
o—*P. oreas*; *a*—*P. artemisiae*

	Jul.-Aug. 1956		Aug. 1957		Oct. 1957		May 1958		Oct. 1958		Aug. 1959	
	o	*a*	*o*	*a*	*o*	*a*	*o*	*a*	*o*	*a*	*o*	*a*
In ravine:												
Exclusive *oreas* area	10	0	29	0	3	1	0	0	0	5	0	10
Zone of overlap	—	—	29	13	0	1	0	0	0	5	0	8
Outside:												
Rim of ravine	—	—	0	16	0	5	0	4	0	6	0	27
Creek west of ravine	—	—	11	0	—	—	—	—	—	7	1	
Total	10	0	69	29	3	7	0	4	0	16	7	46

Trapping was carried out again in the ravine and on the surrounding hillsides for a few days in May, 1958; October, 1958 (by Dr. James Bendell); and August, 1959. No *oreas* were trapped in the ravine after 1957. Apparently the heavy trapping that year aided by natural mortality exterminated the population there. The population in the very small area along the creek west of the ravine was not exterminated, but the ravine has not been repopulated from the creek population. The two *oreas* areas are separated by a strip of habitat one hundred feet wide that is not well suited to *oreas*.

The central part of the ravine had yielded no *artemisiae* prior to the removal of the *oreas* population. One year and two years later this area was occupied by *artemisiae*, but in much lower density than the former *oreas* population. The significance of this in explaining the ecological distribution of the two races will be discussed later.

The easternmost station in this valley was just beyond Princeton, on the east side of the river (2,100 feet). This is in the region of open grassland, and forests of ponderosa pine or Doug-

las fir. Only *artemisiae* was found here. The highest catches were in an open field and on a talus slope, but for the most part the highest populations were found in places where there was good ground cover, such as a talus slope or the bushes and brush piles along the river bank. Most habitats gave much higher yields per unit effort than did similar habitats at Wright's Ranch.

The width of the zone of sympatry cannot be determined from this transect. The races were taken together for more than forty miles along the valley, but the valley cuts obliquely through the zone of sympatry and the zone cannot be nearly this wide. Judging from topography and vegetation it must be from five to ten miles wide, and at least 1,200 feet vertically.

3. *oreas* and *austerus*

Osgood (1909) stated that these forms live under apparently identical conditions, and Svihla and Svihla (1933) took both forms in the same habitats on the Olympic Peninsula. Dalquest (1948: 92) however says that

> within the range of *austerus* and within the range of *oreas* only one subspecies is found whether the habitat be coniferous forest or thickets of alder and willow, but where the ranges of the two subspecies meet *austerus* occurs only in the thickets of aspen and willow and *oreas* occurs only in the coniferous forests.

A large collection of *Peromyscus* from coast forest at La Wis Wis Camp (1,000 feet) in Washington consisted entirely of *oreas*. A logged area in seral coast forest vegetation at Twin Creeks (1,500 feet), Washington, also yielded only *oreas*. These stations were at the foot of the Cascades. In British Columbia similar situations were found at lower elevations, but these yielded only *austerus*. Several stations in coast forest at 1,000 to 2,200 feet elevation on the mountainsides yielded both races. It is difficult to determine any pattern of habitat preference at these stations.

The area that is best understood is the south side of Mount Seymour. The entire mountainside below 2,700 feet was burned many years ago, but above this level there is essentially undisturbed subalpine forest. The coast forest of western hemlock, red cedar, and Douglas fir is replaced by subalpine forest of mountain hemlock, yellow cedar, and subalpine fir at 2,700–3,200 feet.

The distribution of *oreas* and *austerus* on Mount Seymour is loosely correlated with that of both climax forest type and old burn. Only *austerus* was trapped at the lower elevations (mature red cedar-western hemlock forest at 1,500 feet; young red cedar-western hemlock stand at 2,200 feet). From 2,500 to 2,900 feet both *oreas* and *austerus* were taken, usually within the same habitat. Only *oreas* was taken at 3,300 feet, where the forest was an old stand of subalpine species. *Peromyscus* was less abundant here than at lower elevations.

The altitudinal relations of *oreas* with *austerus* are as varied as with the races on the eastern side of the Cascades. On the Pacific Coast of Washington and on parts of the British Columbia coast *oreas* lives at sea level, alone in some places and with *austerus* in others. On Mount Seymour it apparently does not occur much below 2,500 feet. On Mount Seymour *austerus* occurs to at least 2,900 feet, in the Skagit valley to at least 2,200 feet, and yet it was not found at 1,500 feet at Twin Creeks or at 1,000 feet at La Wis Wis. Its occurrence on Mount Seymour seemed to be correlated with the distribution of disturbed coast forest, yet the forest at Twin Creeks was even more disturbed.

III. DISCUSSION OF ECOLOGICAL RELATIONS

It has not been possible to discover the mechanisms responsible for the habitat distribution of *Peromyscus*. The dry forests east of the mountains are inhabited almost exclusively by *artemisiae* and *gambeli*, while the adjacent subalpine forests are inhabitated by *oreas*. The coast forests may be inhabited by *oreas* (my Washington stations), by both *oreas* and *austerus* (most British Columbia stations), or by *austerus* only (Mount Seymour). The lowlands along the coast are primarily the home of *austerus*, though *oreas* also occurs there in many places.

There are many ecological variables in these different communities, and it is difficult to say which are the ones actually determining where an animal lives. Two environmental factors usually were associated with high densities of *Peromyscus*—good ground cover and the presence of water. Ground cover was in the form of thick bushes or herbs, logs, or talus slopes. Water usually was in the form of streams. Good cover and plentiful water usually are associated in this region, but *Peromyscus* has been found abundant in habitats with only one of them. The importance of cover to animals subject to heavy predation is obvious, but the significance of water is not clear. *Peromyscus* trapped in streamside

locations with little ground cover probably nested in better cover nearby.

The factors controlling the distribution and abundance of animals are intimately connected with the problems of their evolutionary history and the nature of adaptation. The things which limit the geographic distribution of an animal may or may not be the things which limit its ecological distribution in a given area. Abundance may or may not be determined by the factors that control distribution.

Among the things that determine the distribution and abundance of a species are: (1) the ability of the species to survive in the area or habitat (adaptiveness), (2) the innate response of the species to the habitat (habitat selection), and (3) the presence of competing species.

1. *Adaptiveness*

Two principal adaptive types are found in *Peromyscus maniculatus* (Blair, 1953*a*)—light-colored forms of the continental interior, with short tails and short hind feet, and darker forms of the mountains and coasts, with long tails and long hind feet. This distribution corresponds to that of the prairies and forests, short-tail mice living on the open prairies and long-tail mice living in forested regions.

The characters of these two groups are associated with the two aspects of survival in a given habitat—finding the necessary requirements of food and shelter, and avoiding being killed by predators. Forest-dwelling *Peromyscus* are known to be partly arboreal in habit, and Horner (1954) has shown experimentally that the long tail characteristic of such races is of value in climbing. This appears to be true of hind foot also. All of the races included in the present study belong to the long-tail group.

Of these races, *artemisiae* and *gambeli* have the shortest tails, and they occur in the most open habitats. They also have hind feet shorter than those of *oreas*. *Austerus*, however, which lives in dense vegetation, has feet as short as those of *artemisiae* and *gambeli*, and tails intermediate between these races and *oreas*. Dalquest (1948) believes that *oreas* is frequently arboreal but that *austerus* is not.

Numerous studies have shown that coloration in *Peromyscus* is cryptic and is adapted to match the color of the background, apparently as a defense against predation. Dark-colored *Peromyscus* are found on dark backgrounds, whether in humid forests or on desert lava beds, while light-colored mice are found on light backgrounds, whether prairies or ocean beaches. The color of the races in this study corresponds in general with the color of the background—*artemisiae* and *gambeli*, the lightest, are found in open, light-colored areas, while *austerus*, the darkest, is confined to the dark forests of the coast.

2. *Habitat Selection*

Horner (1954) reports that races of *Peromyscus* from forested regions showed a greater tendency to climb than did those from open country. Harris (1951) has found experimentally that one of the forest-dwelling races of *maniculatus* preferred a simulated forest environment to simulated grassland, while a prairie-dwelling race preferred simulated grassland. These and other studies suggest that *Peromyscus* has innate reactions to certain features of its environment, reacting positively to some features and avoiding others; in other words, it actively chooses its habitat. This choice is made primarily at the time of sexual maturity, when the young mouse leaves its parental home and wanders off in search of a new one. Even adult mice frequently shift their home ranges. Natural selection may have fixed a preference for the most advantageous habitat as a racial character.

3. *Competition*

Interspecific competition may be defined as interaction among populations of different species involving the use of a common resource and resulting in some adverse effect on one or both populations. Its effect may be direct or indirect, and it may affect the populations in terms of natural selection, population size, or geographic or ecological distribution. Its effect on ecological distribution will be considered here.

If we can show that a species is able and willing to live in a certain kind of habitat but does not do so because of the presence of another species with similar requirements, then we are justified in concluding that competition is limiting the distribution of the absent species. The genus *Peromyscus* occupies most of the terrestrial habitats within its geographic range. Where only one species occurs it occupies a wide range of habitats; where two or more species occur together one or more of them may be sharply limited in habitat distribution (e.g. Dice, 1942; McCabe and Blanchard, 1950). It may be that the habitats in the area of sympatry are not identical to those in the allopatric areas and that

a species is absent from them because it cannot or will not live in them. It may be absent from such habitats, though, because another species is living in them.

The distributional data presented above for *oreas* and the interior races of *maniculatus* show that both species occupy almost all habitats where they occur alone but are more restricted where they are sympatric. At Allison Pass *oreas* was the only race found and there it was taken in all habitats, including a large area of burned-over forest and lodgepole pine woods, both with little cover, as well as the denser, wetter forests. East of Princeton only *artemisiae* was found, and it too was taken in all habitats, including the relatively dense vegetation of a river bank. At Wright's Ranch, where both races were found, they occupied complementary habitats. *Oreas* was taken only in the densest vegetation and *artemisiae* was taken only in other habitats. Both races also were found at Goodfellow Creek and Copper Creek, but at these stations the ecological segregation was less marked. A similar relationship existed between *oreas* and *gambeli* on the Tieton River, though the data are less complete.

In the zone of sympatry *oreas* usually occurs in greater local density than *maniculatus*. This was notably true at Goodfellow Creek, Wright's Ranch, and Clear Lake. It probably is because the habitats occupied by *oreas* are those most favorable for *Peromyscus*. Going from west to east the proportion of the area occupied by *oreas* becomes more restricted, while that occupied by *maniculatus* increases. Nevertheless *oreas* continues to occupy the best habitats, and even at the extreme eastern limit of its range it may occur in greater local concentration than *maniculatus*. Several miles to the east, where *oreas* does not occur, *maniculatus* is found in all habitats, and in greater average density.

These data show that in the zone of sympatry both *oreas* and the interior races of *maniculatus* occupy a narrower range of habitat than they do outside this zone. They suggest, but do not prove, that this habitat restriction results in part from the presence of the other species. If so, the relative advantage of the two species must be in delicate balance, favoring *oreas* in one habitat, *artemisiae* in another, and in a third being so nearly equal that both species can live side by side. Unfortunately, the habitats in the zone of sympatry are not identical to those on either side of this zone, but the differences between, say, the densest forests of the zone of sympatry and the densest forests of the region where *artemisiae* occurs alone seem less important (to the human observer) than the differences between forest and grassland in the *artemisiae* region.

Outside the area of the present study, the forests of the Columbia River valley in south-central British Columbia are similar to those of the coast, including the presence of abundant Douglas fir, red cedar, and western hemlock. *Artemisiae* is the only race of *Peromyscus* in the region, and it occurs in these forests. In the Cascades, where *oreas* also is present, *artemisiae* is not found in such forests. However, *artemisiae* does not extend far into the subalpine forests of the mountains of the Columbia River region, and these forests are largely devoid of *Peromyscus* (Cowan and Guiguet, 1956). In other words, in this region *artemisiae* occurs in some habitats similar to habitats which it does not occupy in the Cascades, but it is absent from some habitats even in the absence of other species of *Peromyscus*.

Similarly, the Cascades of Oregon are much like those of Washington, but *oreas* does not occur in Oregon and there *maniculatus* seems to occur throughout the range (Bailey, 1936). Presumably *P. m. rubidus* on the west and *P. m. gambeli* on the east intergrade in the Oregon Cascades, but I know of no evidence that this actually occurs, nor do I know whether all forested habitats are occupied by *Peromyscus* there.

The strict ecological segregation of *oreas* and *artemisiae* at Wright's Ranch and the small, isolated nature of the *oreas* population there presented an unusual opportunity to carry out a field experiment designed to clarify the nature of the relationship between these two forms. An effort was made to remove the entire population of *oreas* from the ravine where it occurred and observe whether the surrounding population of *artemisiae* would then colonize the ravine.

The success of the experiment depended on the isolation of this population of *oreas* from all others and on removing all the *oreas* present. Trapping outside the ravine showed that the only other population of *oreas* in the area was the small one along the creek just west of the ravine. The initial trap-out was done during August, 1957. Several *oreas* were taken in the ravine in the following October, but none have been taken there since, although a small population has survived along the creek (table 3). It seems that trapping plus natural mortality exterminated the

population of *oreas* in the ravine, and that the ravine has not been repopulated by *oreas* from outside.

With the original *oreas* population removed the ravine was free of *Peromyscus*. If *artemisiae* moved in to occupy the former exclusive *oreas* habitat, it would indicate that *artemisiae* had been kept out only by the presence of *oreas*. If *artemisiae* did not move in and the ravine remained free of *Peromyscus*, it would indicate that *artemisiae* was inherently unwilling or unable to live there and that the presence of *oreas* was irrelevant.

The experiment had to be done quickly and crudely, and the data are of little quantitative value, but the results of the trapping done in October, 1958, and August, 1959, show that *artemisiae* did invade the ravine. In 1959 ten *artemisiae* were taken in the center of the ravine where only *oreas* was taken originally. This seems to be clear-cut evidence that originally the distribution of *artemisiae* was limited by competition with *oreas*. Although *artemisiae* invaded the ravine during the first summer after the removal of *oreas*, a year later it still was present in much lower density than the original *oreas* population. The trapping in both August, 1957, and August, 1959, probably removed almost all of the *Peromyscus* in the ravine, so that the trapping results are somewhat comparable. These figures suggest that the original *oreas* population was about three times as great as the *artemisiae* population two years later.

Peromyscus breeds rapidly and *artemisiae* should have been able to occupy the ravine completely after two breeding seasons. Blair (1940) removed the resident *P. m. bairdi* from an area of about five acres and found a rapid invasion of the area by mice from surrounding areas. Within two weeks the population had reached half its original size. In the present study the *Peromyscus* population of the ravine had not reached half its original size after two years. Stickle (1946) similarly found that a small plot from which the residents had been removed was rapidly invaded by *Peromyscus* from adjoining areas.

If the population of *artemisiae* in the ravine goes no higher than it was in 1959 it will mean that this race is not able to exploit the resources of the ravine nearly as efficiently as *oreas* did. If so, this greater efficiency of *oreas* undoubtedly was involved in the success of *oreas* in competition with *artemisiae* under the conditions present in the ravine. Because *oreas* is more arboreal in adaptation and probably in habit than *artemisiae* its effective habitat in a wooded area is much larger, and this may give it a commanding competitive advantage.

The above data seem to show that *oreas* affected the habitat distribution of *artemisiae*, but they do not show what the mechanism for this was. Competition may result from either direct or indirect interaction of the two species. The interaction is indirect if one species changes the environment so that the other species cannot or will not live there. The most obvious such change would be utilization of the available food or nesting materials until they are present in quantities submarginal for the other species.

A more likely explanation for the absence of *maniculatus* from the ravine is that the species interact directly, because *oreas* could make the environment totally unsuitable for *maniculatus* only by reducing its overall value to itself. *Artemisiae* may avoid places occupied by *oreas* or there may be direct conflict between individuals of the two species when they come in contact. In effect, this would be competition for space.

Peromyscus is not territorial in the sense that it defends its home territory against intruders. Home ranges overlap extensively (Blair, 1942; McCabe and Blanchard, 1950), but these mice tend to occupy nests alone or in temporary association with a member of the opposite sex (Terman, 1961). Terman found that when *Peromyscus m. bairdi* approached a nest box occupied by another individual there would be either a fight or mutual avoidance, but one mouse always left the scene. This exclusive use of nests may act to keep a population dispersed where there are limited numbers of nest sites. McCabe and Blanchard have postulated that the availability of suitable nest sites is a basic population control in *Peromyscus*.

Blair (1953*b*; 1954) found that *Peromyscus* tends to select mates of its own species in the laboratory, while members of different subspecies of the same species mate at random. In the breeding experiments described above there was no evidence of species or subspecies discrimination, but it is probable that under natural conditions such discrimination does occur.

Undoubtedly many things interact to determine the distribution of a species, but I believe that the evidence from this and other studies points to behavior as the key to habitat distribution in *Peromyscus*. The mice choose certain habitats and avoid others. The reaction to certain features

of the environment probably is an innate characteristic of the race. If it is influenced by the presence of another species, we may say that interspecific competition occurs. In some places and at some times this may be the primary factor controlling distribution, while other environmental factors act primarily by controlling the conditions of competition.

DISTRIBUTIONAL AND EVOLUTIONARY HISTORY

Peromyscus oreas has developed substantial, perhaps complete, reproductive isolation from *P. maniculatus*. We believe that reproductive isolation can arise only during geographic isolation and it is probable that at some time in the fairly recent past the parent stock of *oreas* was separated from other stocks of *maniculatus* long enough for reproductive isolation to develop. The most likely time for such isolation was the last glacial period, which had profound effects on the evolution of many kinds of animals in the Northwest. This account of the glacial history of this region is drawn mainly from conversation with Dr. W. H. Mathews of the University of British Columbia.

Almost all of British Columbia and the northern half of Washington were covered by a thick ice sheet (the Vashon-Wisconsin) as recently as 12,000 years ago, and the present biota has developed since then. The ranges of many plants and animals are still in the process of readjustment, distributional limits shifting north or south as time and slight climatic changes permit.

At the glacial maximum British Columbia and northern Washington were under ice, except for isolated mountain peaks, but in southern Washington and in Oregon only isolated valley glaciers were present. Most of the Olympic Peninsula was not glaciated, except for valley glaciers in the mountains. Central Alaska was not glaciated, but the entire southern coast of the state was.

Peromyscus is not a boreal animal, and it almost surely could not have survived the glacial period either in central Alaska, as some mammals did, or on isolated peaks within the glaciated areas farther south. Its mainland distribution must have been limited to the area south of the ice sheet. All the races of the Northwest have entered the region since the end of the last glaciation, the different races either coming in from different directions, following each other in series, or developing *in situ* in response to local environmental conditions. There is reason to believe that each of these processes has occurred in the Northwest.

P. m. austerus of western British Columbia and Washington is similar to and undoubtedly derived from *P. m. rubidus* of the coast of Oregon and northern California. The short-tailed *Peromyscus* east of the mountains presumably entered the area from the south and southeast, various stocks interbreeding as they came in contact and adapting to local environmental conditions.

The postglacial origin of *P. m. macrorhinus* is difficult to explain. Its entire present range was glaciated, and *macrorhinus* is quite distinct from all other mainland races of *maniculatus*. The Queen Charlotte Islands, thirty miles offshore from the *macrorhinus* range, were not entirely glaciated at the Vashon-Wisconsin maximum and they may have served as a refuge for *Peromyscus* at that time. The present race of *Peromyscus* there, *P. m. keeni*, is more like *macrorhinus* than any of the mainland races.

There is no evidence that *oreas* has ever occurred outside its present range. It is probable that it survived the glacial period in southern Washington, which seems to have been covered by subalpine forests at the time. The ancestors of the present-day *maniculatus*, which does not live in such forests, would have been forced farther south. *Oreas* probably developed its morphological distinctness and reproductive isolation at that time, and since the retreat of the glaciers has extended its range farther north. In the meantime other races re-invaded the area from the south and southeast, and in many places occupied territory also occupied by *oreas*. In the 10,000 to 15,000 years since this occurred the two species have been partly sympatric but have maintained their genetic distinctness.

LIFE HISTORY

Life history data from the mice trapped in this study are analyzed elsewhere (Sheppe, in press). Limited data on litter size indicate that *oreas* has larger litters than *maniculatus* (6.1 embryos per litter vs. 5.5). Apparently April through June is the principal breeding season for both species, but while *oreas* ceases to breed by the end of July *maniculatus* continues breeding, at a reduced rate, at least into September.

No observations of *Peromyscus* behavior were made in the field, but casual observations were made of the laboratory colony. On the average, *oreas* was distinctly more active and nervous

than *austerus* and *artemisiae*, and it used the escape jump more often. This greater nervousness may be connected with the failure of *oreas* to breed in captivity.

There was definite social dominance among cagemates. Some mice were killed by their cagemates and others were mutilated, but for the most part dominance did not lead to violence. Killing and mutilation were distinct phenomena, occurring under different conditions and never done by the same mouse. No race or sex had a consistent advantage in dominance, killing or mutilation. *Artemisiae* seemed to be the most aggressive race, *austerus* the least so, both interracially and intraracially. When resting, all of the mice in a cage usually huddled together. Any nest site territoriality or interracial hostility that may occur in nature was not evident under laboratory conditions.

DISCUSSION

The systematic and ecological relations of *P. oreas* and *P. maniculatus* have been discussed at length and speculation has been made on their distributional and evolutionary history. A fairly clear picture emerges—*oreas* is not genetically continuous with the surrounding races of *maniculatus* and it differs from them in many ways. There is a large number of morphological characters by which it differs from most of them, though these characters are not so distinct that all individuals can be positively identified. The habitat requirements of the two species overlap but are not identical. *Oreas* is different in behavior and in physiology (indicated by the apparent difference in time of end of breeding season and by the failure of *oreas* to breed in the laboratory when *maniculatus* was doing so).

It seems probable that during the last glaciation a stock of *Peromyscus* survived in southern Washington and developed into the form that we recognize as *oreas*. At the same time it developed isolating mechanisms which have kept it genetically distinct from *maniculatus* since that species re-entered Washington and British Columbia after the retreat of the ice sheet.

A number of things may be acting to prevent hybridization between *oreas* and *maniculatus*. The most obvious isolating mechanism is allopatry. Some *oreas* populations are in areas devoid of *maniculatus*, but over much of its range *oreas* is sympatric with that species. The habitat differences of the two species provide another means of partial isolation, but again this isolation is incomplete. The extremes of the ecological scale usually are occupied by only one species in the area of sympatry, but intermediate habitats support both species side by side. Partial temporal isolation is indicated by the slight difference in breeding season shown by the field data, but the peak of the breeding season for both species seems to occur at the same time.

These mechanisms together would serve to keep most individuals of the total *oreas* population from breeding with *maniculatus*, but they are not sufficient to have prevented the swamping of *oreas* by *maniculatus* during the thousands of years that they have been sympatric. *Oreas* could have remained morphologically distinct through superior adaptation to local environmental conditions even if it interbred freely with other races, but only if it occupied an exclusive geographic range and contacted other races only peripherally.

There must be something about these species that keeps them from interbreeding even when both of them are in breeding condition at the same time and place. This could be behavioral or physiological-cytological. The experiments of Blair and others have shown that although certain closely related species of *Peromyscus* may be capable of producing fertile hybrids they tend to choose mates of the same species. It is altogether probable that this is true of *oreas* and *maniculatus* also.

The results reported by Liu show that *oreas* and *maniculatus* will mate in the laboratory, but that young are rarely produced by such matings. No information is available on the mating preferences of these species, or on the occurrence of copulation in mated pairs. In the absence of such data we cannot determine the degree of intersterility resulting from physiological or cytological incompatibility. The poor survival record of Liu's few hybrids and the sterility of the only hybrid to reach breeding age suggest that, while these species are partially interfertile, their hybrids have poor viability and may be sterile. This would permit the appearance of F_1 hybrids in natural populations, but would keep both parent stocks genetically pure.

Thus it seems that *oreas* remains distinct from *maniculatus* as a result of the accumulated effects of many highly varied isolating mechanisms. Geographic, ecological, temporal, and behavioral differences between the species all serve to reduce interbreeding. When interbreeding does occur, the young do not survive well, and those hybrids

that reach maturity may be sterile. Much of this is largely speculation, but there is some evidence for all of it.

This hypothesis does not explain why a few populations appear to be intergrades or hybrid swarms, although several miles away both species are found in pure form. It may be that while *oreas* was geographically isolated from *maniculatus* it developed only partial reproductive isolation. This is an unstable condition, and there would be a tendency for it either to become complete, preventing all gene exchange, or to break down altogether, permitting free gene exchange. It may be that both of these processes have taken place in different parts of the area of sympatry of *oreas* and *maniculatus*. Essentially complete isolation seems to be the rule, but there are many possible hybrids in the samples that were examined, and some samples may reflect a complete breakdown of isolating mechanisms.

A similar situation in *Peromyscus* has been described by McCarley (1954), as mentioned earlier. Another example is provided by towhees of the genus *Pipilo* in Mexico (Sibley, 1950; 1954). Sibley believes that hybridization in *Pipilo* has resulted from human disturbance of the habitat, but there is no indication that such disturbance has been responsible for the apparent hybridization between *oreas* and *maniculatus*.

If *oreas* were subject to the introgression of genic material from the surrounding races of *maniculatus*, the *oreas* population at any locality should tend to resemble the race nearest to it. Instead, *oreas* is fairly constant throughout its range, at least in external dimensions. The tail lengths and hind foot lengths of this species from Wright's Ranch, where it is sympatric with *artemisiae*, are almost identical to those of some samples from areas where *oreas* occurs alone. The various races of *maniculatus* show greater geographic variation than does *oreas*, but this is not correlated with the presence of *oreas*.

SUMMARY

1. *Peromyscus oreas* is largely reproductively isolated from *P. maniculatus*. Hybridization may occur, and there may be intergrade populations in some places, but in many places both species are found together in pure form. The ranges overlap widely, but the species maintain their identity. Therefore, *oreas* is removed from the species *maniculatus* and restored to full specific status.

2. In the laboratory *artemisiae* and *austerus* produced fertile hybrids, but *oreas* failed to breed. Other investigators have had difficulty in obtaining *oreas* × *maniculatus* hybrids, and such hybrids have shown low viability and may be sterile.

3. *Oreas* is partially isolated from *maniculatus* in the zone of sympatry by different habitat preferences. Both species have more restricted habitat distribution in the zone of sympatry than where each occurs alone. This restriction may result in part from interspecific competition. When the entire isolated *oreas* population was removed from a large ravine, *artemisiae* from the surrounding hillsides moved into the ravine, although this race was never found there before. This seems to support the idea that competition influences the relative distribution of these forms.

4. *Oreas* probably developed reproductive isolation during the last glacial period, which it may have survived in southern Washington while other stocks of *Peromyscus* were forced farther south.

5. *Oreas* is isolated from *maniculatus* in part by space, by habitat, by breeding season, and apparently by psychological and physiological-cytological incompatibility. The effectiveness of these isolating mechanisms seems to vary from place to place.

APPENDIX 1.

CALCULATION OF EQUAL-FREQUENCY ELLIPSES

Ellipses were calculated to include approximately 95 per cent of the individuals in the sample ($t^2 = x^2 = 5.99$, DF = ∞):

$$\sqrt{(S_x^2 - S_y^2)^2 + 4(S_{xy})^2} = b$$

$$\frac{S_x^2 + S_y^2 + b}{2} = L_1 \qquad \frac{S_x^2 + S_y^2 - b}{2} = L_2$$

$$\frac{L_1 - S_x^2}{S_{xy}} = m \qquad \frac{5.99}{m^2 + 1} = a \qquad \sqrt{aL_1} = c_1 \qquad \sqrt{aL_2} = c_2$$

The coordinates of the major axis are given by:

$$x = \bar{x} \pm c_1 \quad y = \bar{y} \pm mc_1$$

The coordinates of the minor axis are given by:

$$x = \bar{x} \pm mc_2 \quad y = \bar{y} \pm c_2$$

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SHORAN—A PRECISION FIVE HUNDRED MILE YARDSTICK

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(*Read November 10, 1960*)

In 1938 the author was studying the effects of multipath signals on television transmissions, and was intrigued by the simplicity and accuracy of determinations of increased path lengths made possible by measurements of the displacement of the secondary signals on a cathode-ray tube screen. It was apparent that somewhat similar principles could be used in a device in an airplane to measure distances from fixed ground stations for navigational purposes.

The equipment that was then visualized would involve reflected or re-transmitted pulsed radio waves together with a sweeping cathode-ray tube beam as a stop-watch to measure the elapsed round-trip transit time. In that period, before the start of World War II, pulsed radio-wave concepts were not widespread and the term radar had not been coined.

Early analysis of possible circuit configurations indicated the tremendous number of practical aspects that had to be considered. Frequently during the investigations the use of continuous wave signals with measurements in terms of wave lengths of the radiated energy appeared to be simpler and more straightforward than the pulse technique which had been chosen. However, as appealing as that concept seemed in many respects, it has always been resisted on the basis that minute traces of multipath signals, received at either terminal, would cause disproportionately large errors in phase, and thus in distance measurements, without any indication of their presence.

Months of evaluation and test of preliminary equipment designs culminated in a contract award by the Air Force to Radio Corporation of America to construct a blind navigational device utilizing the principles evolved. It was to be used primarily for bombing through the overcast and was named Shoran.

It soon became apparent that the degree of cathode-ray tube deflection linearity which could be realized under all conditions, including variations of orientation in the earth's magnetic field, was obviously insufficient for precision measurement purposes. Therefore, it was necessary to resort to the so-called set-back principle. In this mode of operation the transmitted pulse is radiated prior to display of a zero time marker by an adjustable interval such that it arrives back at the point of origin coincident with the T_0 pulse. Then when the cathode-ray tube indicates pulse coincidence, the dials show the elapsed transit time. Thus, the precision of adjustment of the interval determines the accuracy of Shoran measurements.

The basic adjustable unit as finally developed is a quadrature-phase goniometer. It is supplied with two components of a pure sine wave at a crystal-controlled frequency of 93,109.87 cycles per second. This frequency was chosen because the period of one cycle is nearly equal to the one-mile round-trip transit-time of radiant energy through standard air at sea-level pressure, and because it is also an exact sub-multiple of several frequencies which can be derived from the Bureau of Standards radio transmissions from WWV in Washington, D. C.

The rotor of the goniometer can be turned through any angle in the crossed space and time quadrature fields of the stator to provide a phase delay of the fundamental frequency. One degree is approximately equal to the round-trip transit time equivalent to fifteen feet. The fixed-phase stator voltage is distorted and clipped to form the zero-time marker and the voltage from the rotor is processed to become the transmitter actuating pulse.

Additional goniometers, connected to the basic unit through ten-to-one and one-hundred-to-one step-down gear ratios, are supplied with stator currents at one-tenth and one-one-hundredth of the frequency of the basic unit respectively. These serve to sort out one of each hundred of the 93,000 pulses produced each second. Thus,

* On April 22, 1960, the Society in Executive Session voted to award the Magellanic Premium to Mr. Seeley for his work on Shoran, which is now recognized as the basic method of navigation for ships and planes. The Magellanic Medal was presented to Mr. Seeley on November 10, 1960.

the fundamental unit can be rotated through 36,000 degrees, or the equivalent of one hundred miles, before the distance readings repeat. It has been assumed that the navigator will know the particular hundred-mile segment of distance which will include his position.

For either a determination of exact position, or of the distance between two ground points, it is necessary to have two simultaneous measurements. Therefore, two goniometer chains are included in each Shoran instrument. In operation the transmitter is commutated between the two about five times per second and simultaneously changed in frequency so that each base station will receive and retransmit only those pulses directed to it. Each goniometer chain can be rotated in either direction by a mechanically coupled computer driver at any precisely adjusted rate corresponding to a distance progression velocity between zero and about mach 1, to maintain pulse coincidence.

In the mechanical alignment of the goniometer zeros the phase of the transmitted pulse is set ahead by a fixed-standard angle which is the equivalent of nearly 1,700 feet of distance. This compensates for the time required for the pulse to traverse two transmitters, two selective receivers, and all plane and ground-station cabling between units and antennas. Adjustable delay devices are included in each ground station equipment to allow for variations in required lengths of base station cabling and other variables. Figure 1 illustrates a typical Shoran ground-station set-up. Two corner reflector antennas are mounted atop the collapsible plywood mast. One of these is for the receiver and the other is for the transmitter. The reference point, from which distances are determined, is the bisector of a line between the monopoles of these two antennas.

Both the plane and base-station transmitters develop peak power of about fifty thousand watts. The duty cycle of the plane transmitter is such that the average radiated power is less than fifty watts. However, the ground transmitters are equipped to retransmit all pulses that are received from several planes that may be using that station at the same time so they are constructed to operate with considerably higher average power output when it is necessary. Most Shoran work over the last twenty years has used carrier frequencies between two hundred and three hundred megacycles, corresponding to wave lengths between one meter and one and one-half meters.

When the first version of this equipment was

FIG. 1. A Shoran ground station.

completed, it was installed in a B-17 military plane and ground stations were placed at Montgomery, Alabama, and Tallahassee, Florida. Without previous bombing experience, the author was able to equal the record of trained visual bombadiers in dropping sand-filled practice bombs from 20,000 feet on a target in the bay near Eglin Field, Florida.

The finally devised Shoran timing and indicating unit, which includes the receiver with commutated gain controls, is shown in figure 2 coupled to a bomb-dropping computer. An earth-inductor compass in the tail of the plane and a true air speed indicator also supplied information to the computer. The functions of the computer were to calculate the vector winds, make corrections in the bomb release point and target approach path, then to guide the plane on that path by connections with the auto-pilot and finally to release the bomb at the proper instant. Usually the target-position information and the ballistics of the particular bomb to be released were programmed into the computer before the plane left its home base. Thereafter, unless evasive flight action was necessary, the bombardier had little to do except to adjust the rate and drift goniome-

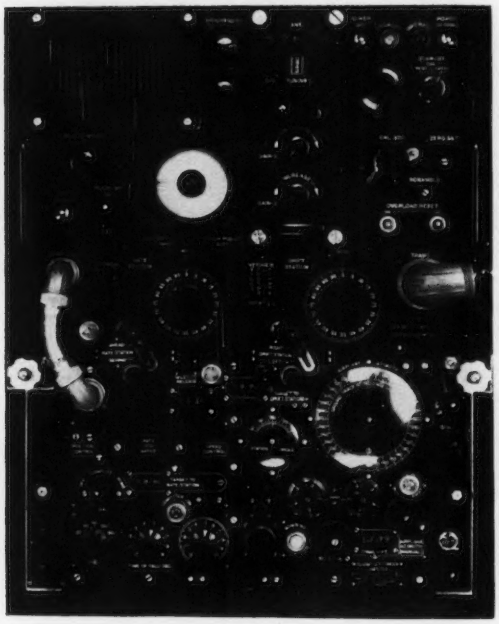

FIG. 2. Shoran plane equipment as used for bombing.

ter drive velocities to maintain pulse coincidence on the cathode-ray tube screen. It is now history that the accuracy of Shoran bombing, as used in the war and in the Korean engagement, exceeded that of any other bombing method regardless of target visibility or identification difficulties.

During early test flights with control stations on the east coast of Florida the author had uncovered an error of several hundred yards in the plotted position of Memory Rock, a small island in the Bahamas out of sight of any other land mass. Subsequent tests with Zenith cameras at fixed ground sites and triggered gas lamps beneath the plane had indicated the probable error of a Shoran navigational fix to be considerably less than the dimensions of the plane.

These results attracted the attention of geodesists who recognized the emergence of a valuable new survey tool. The 7th Geodetic Control Squadron of the Air Force, under the command of Col. Carl I. Aslakson, who was on loan from the U.S. Coast and Geodetic Survey, undertook a project to determine the potential accuracy and best methods of utilization of Shoran for survey purposes. The author worked with this group and devised several equipment modifications which were applied to existing Shoran gear to increase the measurement accuracy several fold over that which had been more than ample for bombing purposes.

In the meantime, the U.S. Coast and Geodetic Survey began using the equipment for hydrographic charting, particularly in the waters surrounding the Aleutian Islands. Perennial fogs in this area had so completely bogged down the operations that had been under way using conventional techniques that the job had appeared interminable. With Shoran it was completed in a few months.

During this same period several large oil companies in the United States had received permission to prospect for oil in some of the huge jungle regions in South America, provided they first established survey control points in these hitherto uncharted and all but impassable areas. This stipulation appeared prohibitive until Shoran survey techniques were evolved and supplied a practical solution to the problem. Some of these companies also used their Shoran gear for position control in their offshore oil prospecting in the Gulf of Mexico.

In August of 1946, as the investigations of the 7th Geodetic Control Squadron began to unfold, the War Department issued a call for a Shoran Geodetic Surveying Conference stating that the results were so amazing in their accuracy and were of such tremendous importance that they would have a direct relationship to many pending Army and Navy projects.

One of those projects was to determine the true position of the islands of the Bahamas, the West Indies, and the Caribbean archipelago with respect to continental North America. It had been realized for many years that relatively extreme gravitational intensity anomalies in those areas indicated probable errors in the vertical at each astronomically determined control point. It was known that in this area a plumb-bob does not point to the center of the earth, the surface of the sea is tilted and the horizon is actually misplaced. But the magnitude and direction of these discrepancies could only be determined by a rigid trilateration survey back to the mainland. Since most of the distances involved were well beyond line of sight, the project had been using large Roman-candle type flares with synchronized sightings by several theodolites at the distant points. This system did not yield particularly satisfying results.

Early in 1945 Colonel Aslakson had undertaken an exhaustive series of Shoran measurements of

the grid line joining five accurately located control points in the Denver, Colorado, area. These ten lines were of various lengths between ninety-eight and three hundred and eight miles.

Later on, this operation was moved into the Florida area and worked with a six-station grid between Daytona Beach and Key West as shown in figure 3. The flat terrain here allowed the use of radio-frequency altimeters, a big help in the study of the true effects of temperature, pressure, and humidity of the air through which Shoran radio waves must travel. There are two of these effects. One is on the velocity of propagation and the other is on the length of the radio path as altered by refraction due to variations in effective density along the route. Today every Shoran survey measurement is adjusted in accordance with temperature, pressure, and vapor pressure information secured simultaneously along the line adjoining the two stations. At present these adjustments are so well understood that errors from this source are negligible.

As this program progressed, the group developed the line-crossing techniques and the corresponding flight patterns that would provide the most dependable information. New photographic recording computers were developed which automatically make between fifty and one hundred

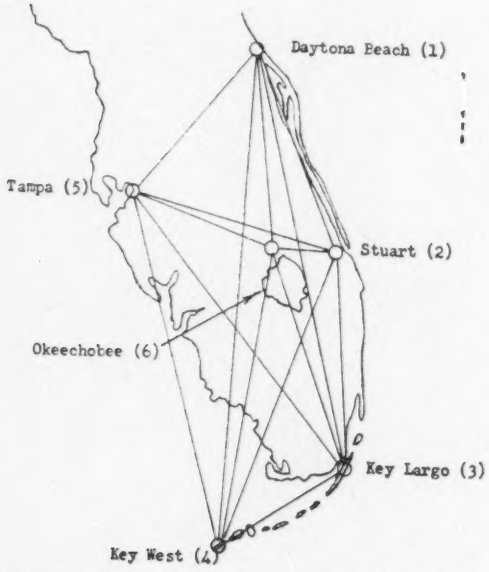

FIG. 3. Distances in Florida surveyed by both land and Shoran means for comparison purposes.

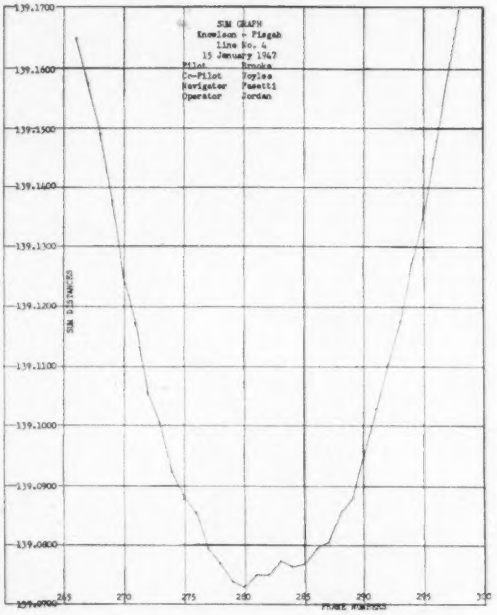

FIG. 4. In Shoran surveying the distances from the plane to each of two ground stations are added as the plane crosses the line adjoining them.

pictures of the two mileage dials on each line crossing so that a plot of the sum of the two distances can be drawn as shown in figure 4. A curve such as this for each line crossing, smoothed by the system of least squares, adjusted for weather, plane altitude, and crystal frequency, and then averaged with data from other crossings of the same line gives the true ground distance between the two positions.

At the beginning of the Shoran development, we used the so-called Anderson value for the constant c, the velocity of radiant energy in vacuo. This was 299,776 kilometers per second. This value had been confirmed by Birge[1] in 1941. However, the refinements in the equipment and in the techniques of use brought to light an error which was proportional to distance. This could only be rationalized by the assumption that the Anderson value was incorrect.

As a result, Aslakson submitted two separate articles to the British publication *Nature* setting forth evidence that the Anderson value was too

[1] Birge, Raymond T., The general physical constants with details on velocity of light only, *Rep. on Progr. in Phys.* **8**, 1941.

low by about sixty parts per million. The first of these articles appeared in Volume 64 in 1949 and the second in Volume 168 in 1951. The final value adopted by Aslakson from all Shoran measurements of known distances was 299,793.1 kilometers per second. This was the same as the value determined by Bergstrand[2] using optical means and published by him in 1950. In 1951 Essen[3] published the results of his work with cavity resonators and proposed a value of 299,-792.8 kilometers per second. This is only one part per million less than the Bergstrand and Aslakson value.

After correcting all previously accumulated Shoran data from the Florida complex with the new value of c, an incompatibility of 35 feet at an azimuth of 39 degrees remained in the location of station (4) at Key West. See figure 3. As a result, a resurvey was recommended and was made by the U.S. Coast and Geodetic Survey. This confirmed an error of 36 feet at an azimuth of 37 degrees and was ample evidence, if more was needed, that Shoran could provide first-order survey accuracy.

By 1950 the so-called Caribbean Area Project of the 7th Geodetic Control Squadron was in full swing. For the first time the true locations of many of the West Indies and Caribbean Islands with respect to the mainland of the United States were being determined. The vector deflection of the vertical could now be established at those islands. Many of the islands were found to be over a mile distant from the positions repeatedly determined by astronomical survey. A few of the positions were over two miles in error.

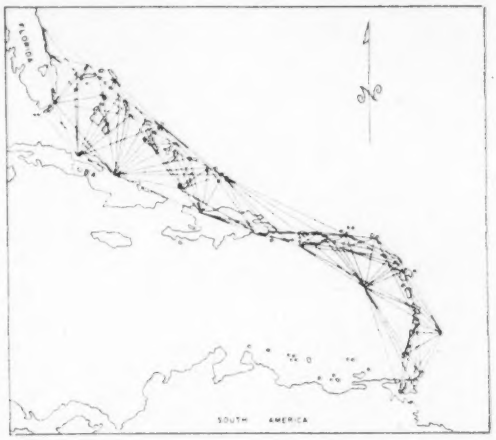

FIG. 5. Shoran survey lines have established the position of islands in the Bahamas and the Caribbean archipelago.

That particular project was completed several years ago. The trilateration construction for this area is strong and the results may be relied upon for first-order survey accuracy. The structure is shown in figure 5.

This work is continuing, not only in the Western Hemisphere, but across oceans and now has linked other continents with ours. Some of the over-water hops have been as long as 885 kilometers. Shoran surveys are daily adding to our knowledge of dimensions and locations on the earth's surface and of the shape of the earth spheroid.

[2] Bergstrand, Erik, A determination of the velocity of light, *Arkiv för Fysik* **2** (15), 1950.

[3] Essen, L., Proposed new value for velocity of light, *Nature* **167**: 258, 1951.

A FLOWER WHERE THE ROADS DIVIDE

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(*Dinner Address, April 21, 1961*)

My title this evening comes from a book for children written long ago by one who in his youth had been a transport rider in the South African veldt in the days of the Boer War. He was a frontier politician, too, and an acquaintance and sometimes a combative critic of that dashing subaltern and penetrating reporter Winston Churchill. The full sentence that I would quote from him runs: "A flower in the hedgerow where the roads divide will mark the spot in one's mind forever; and yet a million more, before and after, and all as beautiful, are passed unseen." And to this innocent expression I would join one very different—Pasternak's burning phrase: "Immortality is only a stronger word for life."

I bring these tributes to innovation and to dynamic immortality to introduce a subject that I believe to be profoundly involved with both. It concerns the origin and the nature and especially the contemporary tasks of a very particular human institution, one, I think, of special significance for our time. Let me cite some familiar examples of it. I may begin with that Accademia dei Lincei, the Italian Academy of the Lynxes, of which Galileo was the sixth member. I may proceed to a scientific society which met privately in Paris from about 1630, for which no specific name seems to have survived, but of which Descartes and Pascal, Desargues and Fermat, were members. Again I may cite a group of Englishmen who about 1645 gathered around the lens-maker Jonathan Goddard and the mathematician John Wallis, to whose treatise *Arithmetica Infinitorum* Newton himself was so greatly indebted. It met regularly for several years, first at Dr. Goddard's lodgings in London, and then, in Wallis' words, at "the Mitre in Wood Street hard by," and finally at Gresham College, which had been founded in 1598 by that same merchant who gave his name to Gresham's Law. And it was at Gresham College that the immortal descendant of this group was born in 1660—the association later to be chartered by Charles the Second as the Royal Society of London for Improving Knowledge, of which John Winthrop, the Governor of Connecticut Colony, was to be a charter member. And finally one must not forget another great contemporary—the French Académie Royale des Sciences, where Christian Huygens was the first secretary.

Then there was another, rather distinct, cluster of similar associations which I would likewise cite. It includes the Manchester Philosophical Society, where the weaver's son John Dalton grew to the stature of a great chemist. It includes the Lunar Society of Birmingham, fired by the active mind of Matthew Boulton, partner of James Watt, which was named from its club rule of calling meetings on nights when the moon was full, so that the members could find their several ways home afterward over the atrocious roads. It includes, again, the Royal Society of Arts and Manufactures, founded in London in 1754.

Divergent as these bodies were in geography and time, and in many of their outward aspects, they shared some characteristics which, I think, are worth close scrutiny. All were formed during a major intellectual revolution, and in milieux of almost explosive expansion in man's practical knowledge of the world. All of them were voluntary associations of mature men, often of widely divergent interests and backgrounds and occupations, but sharing fine minds, daring minds, catholic minds, often truly incandescent minds. Yet more significant, they shared a common passion to explore intellectual frontiers, to initiate, to strike sparks from one another. Each group held as a prime objective the development of an intellectual "crossroads"—a mobile, independent, versatile, sparkling communications center for the life of the mind in its age and for those practical concerns that depended on the intellect. Their members were characteristically of independent temper. It has been estimated that, of a sample of about seventy early Fellows of the Royal Society, more than half were of Puritan affiliation. All the early societies except the

Académie des Sciences were independent of their governments, even in financial matters, and were plagued with fiscal complications, of which the early difficulties of the Royal Society are a vivid example. For all of them, the natural sciences and technology were of prominent concern, but their interests ranged vividly over a wide spectrum in the arts and the humanities and the sciences, and admitted few impassable barriers among them.

It is interesting to notice, too, what these societies clearly were *not*. None included formal teaching among its functions. They all stressed the inclusion of vigorous young men within their councils, often in positions of important influence. But maturity was required: the very young, in the sense of those whose primary need was for instruction, were not among their members. Thus, in a very deep sense they were not universities. Indeed, they had little in common, in their origins, in the patterns of growth, or in their basic functions, even with those medieval primordia of the universities—Corbie or St. Gall or Bobbio, Bec or Cluny, Salerno or Bologna, Paris or Montpellier or Oxford, Chartres or Rheims. Theirs was a different task.

It is revealing, I think, to tabulate the dates of founding of some of these societies. The Accademia dei Lincei, oldest of the first group, probably originated somewhat before 1611—we know that Galileo joined it then, two years after he had built his first telescope. The Royal Society, of course, received its charter in July of 1662, though it had been meeting as a society two years before that. The Académie des Sciences was established in 1666. Thus all the societies in this first group appeared within an interval of about a half-century. The second group shows a similarly compact distribution in dates of origin. The Royal Society of Arts and Manufactures, as I mentioned, was formally constituted in 1754. The Lunar Society came together sometime before 1770; the Manchester Philosophical Society appeared in the 1780's. They all were founded within about thirty years.

Yet a century lay between the brackets of the first group and the second. The compactness of the periods suggests that in each there existed a specific and an imperative cultural demand in response to which these separate clusters of societies were formed. The long interval between the two periods emphasizes both the specificity and the difference of the demands in these two eras. The matter is evidently of great historical interest in its bearing on the nature of the times that called forth the societies, on the nature of the societies themselves, and especially on the nature of the cultural tasks that they performed. But I believe that this interest is more than historical. I believe that it is highly relevant to our own day.

The most striking thing about the span of founding dates of the first cluster of societies is how accurately it included the most explosive phase of the Copernican intellectual revolution, that epoch which embraced the years from Galileo to Newton. The magnitude of that revolution is commonplace. And yet I think it is easy to forget how utterly extraordinary it was. Throughout a whole preceding age, the measure of "truth" in observation had been in large part the success with which impressions of the world could be selected and organized around accepted images. It must have been a titanic achievement to reach the view that investigation itself might determine man's concepts of his world—a revolution vividly symbolized, as Lewis Mumford has sensitively observed, by the general introduction into men's homes of clear glass, replacing the great stained windows of medieval architecture.

That revolution, of course, had *begun* at least as early as the publication of Copernicus' *De Revolutionibus Orbium Coelestium* in 1543, and the work of Tycho Brahe and Johann Kepler. Already, truth for a very few men had come to rest on the quantified, verifiable description of observed phenomena. But these men were clearly most exceptional. By the later seventeenth century, however, when the first societies were well under way, two revolutions had ripened with explosive speed. The philosophy itself had been expanded and had taken on an essentially modern form. A structure of cause and effect had been defined which, as Newton emphasized, should be "kept free of occult influences." Three centuries of intellectual advance were to be built about this revolution of point of view in which, from the days of Newton and Descartes and Hobbes, notions of cause and effect were to be a centrally important feature.

At the same time the social impact of the new philosophy had tremendously widened and deepened, and in good part had become a permanent feature of the culture. It is hard, indeed, to comprehend fully the consuming effects that the Age of Newton had upon culture at large when its basic concepts became truly felt. Trevelyan's memorial to the Age of Queen Anne applied in even greater measure to the years of the Restora-

tion—from which period, indeed, he borrowed no less than three of its giants:

> A nation of five and a half million that had Wren for its architect, Newton for its scientist, Locke for its philosopher, Bentley for its scholar, Pope for its satirist, Addison for its essayist, Bolingbroke for its orator, Swift for its pamphleteer, and Marlborough to win its battles, had the recipe for genius.

Between the early years of Queen Elizabeth and those of Charles II there clearly occurred in British society as a whole the most profound change in ways of looking at the world and at man. Donne and Dryden seem separated by far more than the half-century that historical chronology allots. It seems clear that the early Elizabethan "reasoned" with his entire mind, including in the process faith, intuition, feeling, as well as ratiocination. For the men on the far side of this intellectual watershed, on the contrary, reason and faith were strictly separated. The new pattern took for its model a combination of mathematical deduction with quantitative inductive reasoning. For the post-Restoration writer, the scientific world became the real world. The cosmic view of the Elizabethans, with its accompanying habits of mind, all but disappeared from English literature.

We are indebted particularly, I think, to G. R. Cragg for detecting another highly significant aspect of this revolution. Not only did the whole world outlook of the leaders of a nation undergo a transformation more profound than any that wars or drastic political changes might have heralded during the forty years between the restoration of Charles II and the end of the seventeenth century. The transformation in fact reached far beyond its rare leaders of Newtonian stamp, in scope and in power. So thoroughly did it mold its age that, as Cragg has pointed out, during this period multifarious literary and religious works which were of the second rank nonetheless collectively delineate with accuracy these vast changes of first importance.

This was the kind of social change in which the great societies found and carried out their primary missions. The most obvious initial stimulus to their founding came in the new ideas themselves: in their power and in that high romance which, as Whitehead once remarked, kindles in the first apprehension of major liberating concepts. But the great years, the years when the societies rose to true social significance, were those when the whole culture was already in ferment. Then it was indeed that the chances came to cultivate the flowers that mark the road's divide, to enhance their brilliance, to win their permanence.

This, however, is only half the story. For without the technical revolution that preceded and accompanied the intellectual one inspired by Newtonian concepts of the world the general transformation ignited by these concepts could never have come about. That practical strain, indeed, had long exercised a very deep substantive influence on the intellectual revolution itself. It had surely been no accident that the development of mathematics was greatly stimulated in the later Renaissance years, when the commerce of a predominantly Italian trading culture was expanding so rapidly. It was surely no accident, again, that the years when the primitive arts of navigation served a primary frontier were also the years when the first telescopes were designed, and when the study of optics and hydraulics and the building of clocks pre-empted men's enthusiasms and preoccupied their minds.

This practical technology was as important as the great concepts themselves in the climate to which the new societies were addressed. And the societies were acutely conscious of this. At the Académie des Sciences, Huygens was deeply involved in investigating the pendulum as a practical device of clockwork, and was making significant contributions to the design of the balance spring. It has been estimated that nearly sixty per cent of the problems handled by the Royal Society in the first thirty years of its existence were inspired by the practical needs of public use. Robert Hooke, appointed in 1662 as Curator of the Society, was assigned the formidable duty of bringing in three or four new technical experiments at each meeting.

How fundamental was this practical element in the function of the societies is yet more vividly emphasized in the original purposes of all the members of the second group. The Royal Society of Arts and Manufactures was founded explicitly to encourage practical and applied science. The Manchester Philosophical Society originated in a group of practical men who had been students at Warrington Academy, where Joseph Priestley, originally a teacher of English and languages, was to become the greatest chemist of his day. The Lunar Society was built by men like Matthew Boulton, the partner of James Watt in the building of steam engines, and John Roebuck, a pioneer in the chemical industry who took a share in Watt's patent rights, and Josiah Wedgwood. Their practical aims, in fact, were no different

from the early ones of the Académie des Sciences and the Royal Society. Why, then, did these new societies appear at all when their far more distinguished predecessors still occupied the field?

There must be many answers to that question. Two speculations that intrigue me are suggested by the clustering of the founding dates of the societies and the long separation between the times of appearance of the first and second groups to which I have referred.

The first speculation concerns possible developments within the earlier societies themselves, responding to subtle changes in the science of that time. There is much to indicate that, though Newton himself was of eminently practical as well as theoretical bent, the very comprehensiveness of his ideas, and especially the power of their formulation, inspired widespread efforts to similarly order and systematize other branches of scientific inquiry still in the empirical and descriptive stage. Some of those branches were not ready for such treatment, and their growth could only be retarded by it. There is a suggestion that by the time of Newton's death, in part perhaps because of the very prestige that his methods of inquiry had achieved, the work of the inventor and the empirical experimenter may have been considered less central to scientific advance than it had earlier been. For a relatively brief but highly critical period, despite the fact that James Watt, for example, was a Fellow, the Royal Society itself may well have verged on an academic position that it had eloquently scored in Oxford and Cambridge a century earlier. Now the dates of founding of the new societies roughly match this period. So there is a suggestion that practical men, perhaps responding to a climate, were stimulated to form associations of their own.

But the second aspect is to me more interesting. The earlier group of societies came into being in a preindustrial culture, living largely by trade. The later group entered a milieu already shaped by the first Industrial Revolution. One imagines that the tasks of assimilating an intellectual and a practical revolution to these two kinds of society may have differed in important and subtle ways. It may well be that the older Societies could not adapt at once with full effectiveness to the new environment. The most immediately effective response to the radically new demand may well have been the younger societies, born into the culture that they served.

Let me now come closer to our day. It is revealing to reflect how many of these societies have persisted to the present, through all the turbulence and change of two or three centuries. On the whole, moreover, they have greater vitality today, and fill more dynamic roles, than ever before. The Accademia dei Lincei is the Accademia Nazionale dei Lincei, a scientific body of stature and importance. The Académie Française has if possible increased its prestige. The Manchester Society and the Lunar Society have been transformed, but the Royal Society of Arts carries on with undiminished vigor in its beautiful London quarters in John Adam Street. And of the Royal Society, in its three hundred and first year, one can say nought further. That dynamic immortality has been achieved which, at last, is but a stronger word for life.

What does this say about the deepest currents of our own times, flowing beneath the immense shifts of direction and of scale that have preoccupied our culture in these three centuries? What does it say about the societies themselves; about their relevance for the present and the future?

When the British Queen ascended the throne in 1952, a sentiment was widely voiced in England that there was marked the beginning of a second Elizabethan age. The flaws of detail in such a generalized comparison were quickly recognized. But in a far more universal sense, I think, it conveyed a vivid truth. For beyond doubt we are living once again through a comparatively tremendous shift in science and philosophy. Like the earlier revolution, its core lies in radical changes in fundamental ideas, in radical readjustments of man's basic concepts of the world—the most profound, indeed, in the last three hundred years. As in Newton's day, it was set off by liberating new ideas, by those revolutionary physical concepts that now permeate our lives—the ideas of relativity and of uncertainty. Central in that revolution, too, are the new concepts of chance, which, as Bronowski has suggested, may ultimately prove as great a unifying principle for the diverse branches of science as were the concepts of causality in the days of Newton and Descartes and Hobbes. No better example of this, perhaps, can be offered than the quantitative and statistical studies of population genetics and population structure that in recent years have so illumined our understanding of assemblages of living things.

There are of course many far-ranging aspects of the current intellectual revolution which are of poignant social import, paralleling in their impact

those of Newton's day. If the Newtonian revolution, for instance, established the concept of the detached, confirmable individual observation as a criterion of truth in nature, a truth from which the observer could be set apart, we must master the far more subtle concept of the interaction of nature and of observer as parts of one coherent system. Again, we still tend to conceive the ultimate task of science as the search for "truth" in its earlier definition, in terms of individually verifiable "absolute" observations. Perhaps we must redefine that task in more comprehensive ways. Perhaps, following a suggestion of Martin Johnson made a number of years ago, we will come to think of scientific truth primarily as a measure of communicability and coherence of systems of thought, as a property of interchangeability, as it were, between observers on the one hand and scientific propositions on the other. There can be few more practical testaments, indeed, to the concept that all scientific knowledge forms a close-woven nexus than the rich history of parallel scientific discoveries and insights attained by workers far apart, who have not been directly in communication.

There is every evidence, then, that this intellectual revolution of our day will be at least as far-reaching in its social consequences as that which confronted the men of the Restoration. And there is another important parallel between our times and theirs. As in that period, the practical technology of our age is likewise in a revolution hitherto unparalleled. One need hardly mention the well-worn subject of space exploration, stimulating the imagination of a whole generation as much as did Galileo's telescopes. Nearer home, the physical power that we have won from nature in our day is evidently of a wholly different order from anything we have known before. With that conquest, the practical tasks of technology have in some measure subtly shifted emphasis from the discovery of new sources of power in nature to yet more challenging domains—to the organization and modulation and control of that power, to new modes of communication in the transmission, but more especially in the generation and the analysis of messages, and, as in the processes of life and of mind themselves, to ways of predicting the future.

I come to a final point of convergence between our times and the periods when the societies were founded which seems to me most noteworthy. As I have said, there is much to suggest that the greatest of all the contributions of the societies at their beginnings were made not so much in the *initiation* of intellectual or technical revolutions as in the performance of a yet more awesome function—that of pioneering in the vast cultural tranformations that winged so swiftly as the revolutions took hold. Now it seems evident that once again we are midstream in wide cultural changes, consequent once more on intellectual and technical revolutions—those revolutions of the first half of the twentieth century which have been as profound as any that faced the men of the Restoration, and have come with comparably explosive speed and power.

So the processes of change which brought forth the societies, and which confront them with their greatest tasks today, converge at levels that are at once subtle and highly significant. Today is clearly critical. What then of the future? Such was the power of the Newtonian concepts and their impress upon Western thought that three centuries of intellectual and practical advance were supported by their vast potential. Will our contemporary revolution support our verve as long as did the first? Can we extrapolate from that earlier period? Will the challenges of, say, the 1980's for the societies bear any resemblance to those, say, of the 1880's?

In some respects, I think, there may be common denominators, though of a relative kind and likely to have quite different implications. We think, for instance, of the expansion of scientific effort in our day as explosive—a doubling every ten to fifteen years. Yet one recalls that this *rate* has in fact remained fairly constant since the days of Newton—and wonders rather what will happen in our culture if the nature of population growth itself may eventually retard that rate. We are concerned about the ever-intensifying problems of communication between scientific and non-scientific fields, and among the scientific disciplines themselves, and sometimes almost despair at their complexity and magnitude and difficulty. Yet it is worth remembering that these same problems vexed the men of Newton's age—and indeed one of the great tasks of the societies was precisely that of alleviating them. We are concerned with such problems as the "over-ordering" of branches of science not yet ready for the discipline and the confines that we would like to put upon them—such premature order, for instance, as retarded and deflected early approaches to the subject of genetic recombination in our own time. It is easy to forget that just such over-ordering on a far grander scale probably contributed impor-

tantly to the very situation in eighteenth-century science which the younger group of societies were formed in part to rectify.

Such problems, and the challenges that they pose today, clearly have a continuity with those of the past. But it would be dangerous to forget that major qualitative differences accompany major changes of scale, in intellectual and social realms no less than in those of technology. Consider, for instance, the problems that must surely follow from the unexampled secularization of knowledge which dominates our time, and especially scientific and technical discovery. I use that term broadly and loosely, for want of a better, to mean the organization and the systematization and the taking-for-granted of knowledge won which so typically accompanies its integration into an advanced society. What happens to the compelling quality of a comprehensive new system of ideas, or great new conquests of nature, or great new inventions, as the concerns primarily related to their social integration replace those of discovery with its early wonder? What happens not only to quality, but to standards of quality?

We have many historical examples of secularization in this sense on a grand scale, vividly illustrating its opposing significances for a culture. Consider, for instance, the secularization of the art of writing, still going forward in some newly literate societies: the thrill in the fact of writing itself, the emphasis on penmanship, the special position of the amanuensis, comparable to that of the reckoner in figures in cultures where elementary arithmetic was or still is a great accomplishment. Contrast these with the attitudes of more sophisticated cultures toward innovation in the same arts, where the arts themselves have already virtually transformed the cultures. Think, again, of the invention of block printing and of movable type—of the vital foundation that it laid for the modern cultural revolution, which yet was accompanied by a contemporary apprehension so serious that printing seems to have been banned in certain monasteries in dread of the loss of quality which it must bring in the copyist's art. Think, in our day, of the similar dichotomy in the explosive secularization of literature achieved through the medium of the paperback book.

The challenge is important. For perhaps it is deeply characteristic of the human mind that as the systematization and the organization of knowledge and of technical power progress the vividness and the color and the style that initially surround them become progressively harder to maintain. Yet it is just at this point that these qualities are most vitally important. For verve and style and romance and deep individual involvement are indeed inseparable from quality, not only of the effort itself, but of the very culture which it serves.

This was not a basically new problem for the societies in the mid-nineteenth century. It was not a new prospective problem for the Linnean Society when the Darwin and Wallace papers were read before it in 1858, though the Society was apparently largely unaware of it at the time. Think, indeed, of the successive stages in the social adoption of the ideas surrounding Darwinian evolution, and how magnificently they illustrate these difficulties—the early white-hot flame of cognition, the later occlusion of communication and failures of understanding that not even a Huxley could rectify, the mistaken interpretations, the curious distortions, and finally the incorporation of a revolutionary body of ideas so deeply into the culture that the dissection of their original sources becomes a futile as well as a fruitless exercise.

But if this challenge to the societies is not new in principle, it is today radically different in scale and difficulty. In their early days the societies were greatly aided by the fact that the whole basis of scientific knowledge was still, in large part, in a fresh stage of appreciation. Such appreciation persists today, of course, for a body of knowledge which, in absolute terms, is far greater. But it is no longer written on a virgin slate. Now it is projected in the context of a vast background already at the stage of systematization, already at the stage where the ends of the investigation or the development, however exciting and unexpected they must be in detail, are in their essence really known. This poses quite new problems for the maintenance of wonder and of verve. It is a curious and possibly a relevant illustration that, as Dennis Gabor has observed, despite the incomparably exciting future that is surely a most likely prospect of our age, Utopian literature has been dead for at least thirty years.

Trevelyan's environment which had the recipe for genius and in which the new societies began was a nation of five and a half million. What shall we say of the challenges from a nation of one hundred and eighty million, from a world of perhaps two billion nine hundred million, with at least as high a proportion of potential genius in

their make-up? What shall we say of the challenge in a generation in which possibly ninety per cent of all the scientific minds that have existed since the Newtonian revolution contemporarily carry on their work?

But quite apart from these more detailed questions—though of course indissolubly linked with them—what of the primary role of the societies in our time, and especially in the future? Here, I think, the answer is simpler, and clear, and unequivocal.

The great role that challenges the societies today, and will fall to them tomorrow, is surely of a dynamic immortality. For our own culture, it may perhaps best be summed as the maintenance, in a vast and explosively growing and changing milieu, of all that is most essential and most poignant in the tradition of the individual, innovating Liberal—in the tradition, really, of the profoundly unconforming man. Not easiest, but among the most significant, responsibilities accompanying such a mission will be the maintaining and the widening of opportunities for the constant growth and the continuing perfectibility of that individual in a culture that is by its very nature, and, most significantly, by its very need, profoundly affected by all the forces of intense organization.

And there is a related subtle and powerful responsibility of guidance for which all the experience of the societies has peculiarly prepared them. Long history has demonstrated that a nation will be great in those areas where it recognizes, cultivates, and demands greatness. This proposition can also be framed in its converse: "Where greatness is perceived, demanded, cultivated, rewarded, there will a society be great." This also is a definition of the mission within the context of our culture.

But the challenges, of course, are also of world proportions. There is a profound and solemn truth in the observation that the power to inspire men with tolerance faces its most acid test in a world of more than one competing great intolerance. The world of competing great intolerances is the one in which we live. This formidable dilemma, at last, poses the greatest of all the subtle and difficult tasks to which the great societies are heir.

Now I have been speaking this evening about a class of human institutions in very general terms, and in the context of history. I have taken my examples from remote periods and from European settings because they offer such fine laboratories of inquiry. But my inner thoughts have settled nearer home, in geography and time. They could not but center on a body formed in 1743—neatly within the distribution of founding dates of the second group of British societies that I have cited—founded by that journeyman printer from Boston who while working in London in 1725 had written with a characteristic mixture of enterprise and humility and pecuniary shrewdness to Sir Hans Sloane of the Royal Society, offering to sell him a purse made of asbestos—a successful sale, it should be noted. Of course my thoughts are dominated by the luminous past and the infinitely challenging present and future of Franklin's band of "virtuosi or ingenious men," that lineal descendant of the Royal Society of London for Improving Natural Knowledge, the American Philosophical Society, Held at Philadelphia, for Promoting Useful Knowledge.

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